



U.S. ARMY
MATERIEL COMMAND

PROGRAM MANAGER FOR ROCKY MOUNTAIN ARSENAL



— COMMITTED TO PROTECTION OF THE ENVIRONMENT —

**COMPREHENSIVE AIR QUALITY AND
METEOROLOGICAL MONITORING PROGRAM
CONTRACT NO. DAAA15-88-D-0022
AIR QUALITY DATA ASSESSMENT
REPORT FOR FY91
VOLUME II
FINAL VERSION**

Woodward-Clyde Consultants



Consulting Engineers, Geologists and Environmental Scientists
Stanford Place 3, Suite 1000
4582 South Ulster Street Parkway
Denver, Colorado 80237
(303) 694-2770

REQUESTS FOR COPIES OF THIS DOCUMENT
SHOULD BE REFERRED TO THE PROGRAM MANAGER
FOR THE ROCKY MOUNTAIN ARSENAL CONTAMINATION CLEANUP,
AMXRM-PM COMMERCE CITY, CO 80022.



ROCKY MOUNTAIN ARSENAL • COMMERCE CITY, COLORADO • 80022-2180

**COMPREHENSIVE AIR QUALITY AND
METEOROLOGICAL MONITORING PROGRAM
CONTRACT NO. DAAA15-88-D-0022
AIR QUALITY DATA ASSESSMENT
REPORT FOR FY91
VOLUME II
FINAL VERSION**

**Prepared by:
WOODWARD-CLYDE CONSULTANTS
Prepared for:
U.S. ARMY PROGRAM MANAGER'S OFFICE
FOR ROCKY MOUNTAIN ARSENAL**

**THE USE OF TRADE NAMES IN THIS REPORT DOES NOT CONSTITUTE AN OFFICIAL
ENDORSEMENT OR APPROVAL OF THE USE OF SUCH COMMERCIAL PRODUCTS.
THE REPORT MAY NOT BE CITED FOR PURPOSES OF ADVERTISEMENT.**

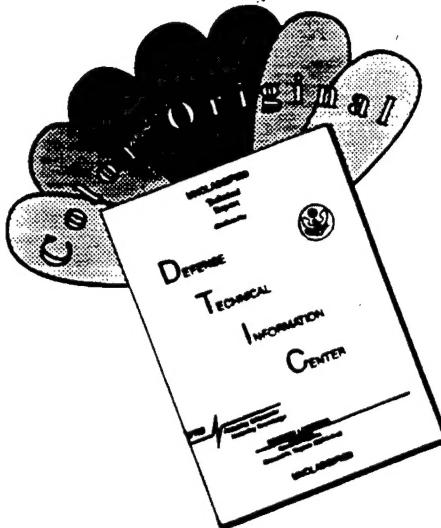
REPORT DOCUMENTATION PAGE

*Form Approved
OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY <i>(Leave Blank)</i>			2. REPORT DATE 12/00/92		3. REPORT TYPE AND DATES COVERED FINAL	
4. TITLE AND SUBTITLE COMPREHENSIVE AIR QUALITY AND METEOROLOGICAL MONITORING PROGRAM, AIR QUALITY DATA ASSESSMENT REPORT FOR FY91, FINAL VERSION			5. FUNDING NUMBERS DAAA1588D0022			
6. AUTHOR(S)						
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) WOODWARD-CLYDE CONSULTANTS			8. PERFORMING ORGANIZATION REPORT NUMBER 93026R01			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSORING/MONITORING AGENCY REPORT NUMBER			
11. SUPPLEMENTARY NOTES NONE						
12a. DISTRIBUTION/AVAILABILITY STATEMENT APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED				12b. DISTRIBUTION CODE		
13. ABSTRACT <i>(Maximum 200 words)</i> <p>THIS REPORT FOCUSES ON RESULTS OF THE CMP FOR FY91 AND INCLUDES ANALYSES AND COMPARISONS TO DATA FOR PRECEDING MONITORING PROGRAMS AT RMA AND FOR OTHER PROGRAMS WHICH RAN CONCURRENTLY. THE CMP FY91 DATA, IN CONJUNCTION WITH CMP FY88, FY89 AND FY90 DATA, BASIN F REMEDIAL MONITORING PROGRAM DATA, AND BASIN F POST-REMEDIATION MONITORING PROGRAM DATA PROVIDE COMPREHENSIVE DATABASE FOR EVALUATING REMEDIAL PROGRESS RESULTING FROM THE BASIN F CLEANUP PROGRAM. ONE OBJECTIVE OF THIS REPORT IS TO PROVIDE AN ASSESSMENT OF THE COMBINED DATABASE IN THE CONTEXT OF REMEDIAL PROGRESS. (THIS REPORT CONSISTS OF FOUR VOLUMES AND TWO HIGH DENSITY DISKETTES CONTAINING THE MAJORITY OF THE TABLES PRESENTED IN VOLUME IV.)</p>						
14. SUBJECT TERMS CONTAMINANT SOURCES, HEALTH AND SAFETY, METEOROLOGY					15. NUMBER OF PAGES 4 VOLS., 2 DISKETTES	
					16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT		20. LIMITATION OF ABSTRACT		

DISCLAIMER NOTICE



**THIS DOCUMENT IS BEST
QUALITY AVAILABLE. THE COPY
FURNISHED TO DTIC CONTAINED
A SIGNIFICANT NUMBER OF
COLOR PAGES WHICH DO NOT
REPRODUCE LEGIBLY ON BLACK
AND WHITE MICROFICHE.**

TABLE OF CONTENTS

VOLUME I

<u>Section</u>	<u>Page</u>
EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION	1-1
1.1 SITE BACKGROUND INFORMATION	1-4
1.2 POTENTIAL CONTAMINANT SOURCES	1-4
1.3 RESULTS OF CMP FY90 ASSESSMENT	1-5
2.0 REGIONAL AND LOCAL AIR QUALITY AND METEOROLOGICAL CHARACTERISTICS	2-1
2.1 AIR QUALITY	2-1
2.2 METEOROLOGY AND AIR QUALITY	2-1
3.0 PROGRAM STRATEGY AND METHODOLOGY	3-1
3.1 GENERAL BACKGROUND	3-1
3.2 CMP AIR QUALITY MONITORING PROGRAM	3-2
3.2.1 Siting Criteria	3-2
3.2.1.1 Proximity to Sources or Boundaries	3-3
3.2.1.2 Wind Speed/Direction	3-3
3.2.1.3 Topographical Features and Obstructions	3-4
3.2.1.4 Continuity With Previous Monitoring Programs	3-4
3.2.2 The CMP Air Quality Monitoring Network Locations	3-5
3.2.2.1 Permanent Stations	3-5
3.2.2.2 Portable Air Quality Monitoring Stations	3-5
3.2.3 Air Quality Monitoring Strategies	3-6
3.2.3.1 Baseline Monitoring	3-6
3.2.3.2 Worst-Case Assessment	3-7
3.2.3.3 Remedial Assessment	3-7
3.2.3.4 Criteria for Gaseous Pollutant Assessment	3-8

TABLE OF CONTENTS (Continued)

<u>Section</u>		<u>Page</u>
3.2.4	Air Quality Monitoring Methods	3-8
3.2.4.1	Total Suspended Particulates (TSP)	3-9
3.2.4.2	Particulate Matter Less than 10 Microns (PM-10)	3-9
3.2.4.3	Asbestos	3-10
3.2.4.4	Volatile Organic Compounds	3-10
3.2.4.5	ICP Metals and Arsenic	3-10
3.2.4.6	Organochlorine Pesticides (OCP)	3-11
3.2.4.7	Mercury	3-11
3.3	THE IRA-F AIR MONITORING PROGRAM	3-12
3.3.1	Background	3-12
3.3.2	IRA-F Sampling Strategy	3-12
3.3.3	The Air Stripper Monitoring Program	3-13
3.3.4	Cap and Vent Monitoring	3-14
3.4	METEOROLOGICAL MONITORING PROGRAM	3-14
3.4.1	Location of Meteorological Monitoring Stations	3-14
3.4.2	Monitoring Equipment and Strategy	3-15
3.4.3	Data Acquisition	3-15
3.4.4	Data Applications	3-15
3.5	CONTINUOUS AIR MONITORING PROGRAM	3-16
3.6	LABORATORY ANALYSIS PROGRAM	3-16
<u>VOLUME II</u>		
4.0	RESULTS OF FY91 PROGRAM	4-1
4.1	BASIS OF AIR QUALITY DATA EVALUATION	4-1
4.1.1	Computerized Documentation	4-2
4.1.2	Remediation Evaluation	4-4
4.1.3	Dispersion Model Applications	4-4
4.1.4	Source Emission Factors	4-6

TABLE OF CONTENTS (Continued)

<u>Section</u>		<u>Page</u>
4.2	TOTAL SUSPENDED PARTICULATES (TSP)	4-7
4.2.1	CMP FY91 TSP Results	4-7
4.2.2	Assessment of Basin F TSP Post-Remedial Impacts	4-10
4.2.2.1	CMP TSP Monitoring Results	4-10
4.2.2.2	Basin F TSP Monitoring Results	4-11
4.2.2.3	Analysis of Combined CMP/Basin F TSP Monitoring Results	4-15
4.2.2.4	Individual Day Remedial Assessment Comparisons	4-16
4.2.3	RMA TSP Casual Effects	4-17
4.2.4	Denver Metropolitan Area TSP Influences	4-20
4.2.4.1	CMP FY91 Period Results	4-20
4.2.5	Analysis Implications for Mitigation and Controls	4-22
4.2.6	Summary	4-22
4.3	RESPIRABLE PARTICULATE MATTER	4-23
4.3.1	PM-10 Monitoring Program	4-23
4.3.2	Basin F PM-10 Impacts	4-25
4.3.2.1	CMP Data	4-25
4.3.2.2	Basin F Data	4-27
4.3.2.3	Combined Basin F and CMP Data Analysis	4-27
4.3.3	Metropolitan Denver PM-10 Data	4-28
4.3.4	Summary of PM-10 Analysis	4-29
4.4	METALS	4-30
4.4.1	Metals Monitoring Strategies	4-30
4.4.2	CMP FY91 Metals Monitoring Results	4-31
4.4.2.1	March 19, 1991	4-33

TABLE OF CONTENTS (Continued)

<u>Section</u>		<u>Page</u>
	4.4.2.2 March 25, 1991	4-34
	4.4.2.3 July 2, 1991	4-34
4.4.3	Assessment of Basin F Metals Impacts	4-35
	4.4.3.1 CMP Data	4-35
	4.4.3.2 Basin F Data	4-36
	4.4.3.3 Combined CMP and Basin F Data Analyses	4-39
4.4.4	Analysis of Metals Source Factors	4-40
4.4.5	Assessment of Metals Concentrations Relative to Toxic Guidelines	4-42
4.4.6	Summary	4-45
4.5	ASBESTOS	4-47
4.6	VOLATILE ORGANIC COMPOUNDS (VOCs)	4-48
	4.6.1 VOC Monitoring, Analysis and Reporting Strategies	4-48
	4.6.2 CMP FY91 VOC Monitoring Results	4-51
	4.6.2.1 Basin F High Event Scenario, June 12-13, 1991	4-53
	4.6.2.2 Quench Incinerator Construction Area High Event Scenario, June 20, 1991	4-54
	4.6.2.3 South Plants Subdrain Construction High Event Scenario, June 26, 1991	4-55
4.6.3	Basin F VOC Impacts	4-56
	4.6.3.1 CMP Data	4-56
	4.6.3.2 Basin F Data	4-57
	4.6.3.3 Combined CMP and Basin F Data Analysis	4-60

TABLE OF CONTENTS (Continued)

<u>Section</u>		<u>Page</u>
4.6.4	Additional VOC Monitoring Considerations	4-61
4.6.4.1	Seasonal VOC Impacts	4-61
4.6.4.2	Metropolitan Denver Area VOC Emissions	4-62
4.6.5	Summary of Results and Assessment of VOC Toxicity Levels	4-66
4.6.6	VOC Nontarget Analyte Results	4-73
4.7	ORGANOCHLORINE PESTICIDES (OCPs)	4-76
4.7.1	Monitoring, Analysis and Reporting Strategies	4-76
4.7.2	CMP FY91 OCP Monitoring Results	4-77
4.7.2.1	Basin F High Event Period, June 12-13, 1991	4-79
4.7.2.2	Quench Incinerator Construction Area High Event Period, June 20-21, 1991	4-80
4.7.2.3	South Plants Subdrain Construction High Event Period, June 26-27, 1991	4-81
4.7.3	Basin F OCP Impacts	4-82
4.7.3.1	CMP Data	4-83
4.7.3.2	Basin F Data	4-83
4.7.3.3	Combined CMP and Basin F Data Analyses	4-85
4.7.4	Summary of Results and Assessment of OCP Toxicity Levels	4-86
4.7.5	Seasonal Considerations	4-90
4.8	AIR STRIPPER OFF-GAS TESTING	4-91
4.9	REAL-TIME CAP AND VENT MONITORING	4-94
4.9.1	Program Description	4-94
4.9.2	Real-Time Monitoring Results	4-95

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
<u>VOLUME III</u>	
5.0 CONTINUOUS AIR MONITORING PROGRAM	5-1
5.1 PROGRAM OVERVIEW	5-1
5.2 ANALYSIS OVERVIEW	5-2
5.3 CARBON MONOXIDE	5-3
5.4 OZONE	5-4
5.5 SULFUR DIOXIDE	5-5
5.6 NITRIC OXIDE, NITROGEN DIOXIDE, AND NITROGEN OXIDES	5-6
5.7 REGIONAL EMISSION SOURCES IMPACTING RMA	5-7
5.7.1 February 2, 1991	5-8
5.7.2 August 31, 1991	5-9
6.0 PHOTOGRAPHIC VISIBILITY STUDY	6-1
6.1 HIGH WIND DUST EVENTS	6-2
6.1.1 February 20, 1991	6-2
6.2 BROWN CLOUD EVENTS	6-3
6.2.1 March 19, 1991	6-4
6.3 SUMMARY	6-5
7.0 METEOROLOGICAL MONITORING AND DISPERSION MODELING PROGRAMS	7-1
7.1 METEOROLOGICAL PROGRAM OVERVIEW	7-1
7.1.1 Program Objectives	7-1
7.1.2 Data Recovery	7-2
7.1.3 Databases	7-2

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
7.2 SUMMARY OF RESULTS 7-3	
7.2.1 Temperature 7-4	
7.2.2 Relative Humidity 7-4	
7.2.3 Barometric Pressure 7-5	
7.2.4 Solar Radiation 7-5	
7.2.5 Precipitation 7-5	
7.2.6 Winds 7-6	
7.2.7 Atmospheric Stability 7-6	
7.3 SEASONAL AND DIURNAL INFLUENCES 7-7	
7.4 SUMMARY AND CONCLUSIONS 7-8	
7.5 RMA METEOROLOGICAL STATION COMPARISONS 7-9	
7.6 ATMOSPHERIC DISPERSION MODEL 7-11	
7.6.1 Model Approaches 7-11	
7.6.2 Additional Model Approaches and Analyses 7-14	
7.6.2.1 Source Emissions Characterization 7-14	
7.6.2.2 Remedial Activity Production Data 7-15	
7.6.2.3 Local and Regional Emissions Inventory 7-15	
7.6.2.4 Empirical/Statistical Adjustments 7-16	
8.0 QUALITY ASSURANCE PROGRAM 8-1	
8.1 OVERVIEW AND GENERAL GUIDANCE 8-1	
8.2 LABORATORY QC AND QA PROGRAM OVERVIEW 8-3	
8.3 FIELD QUALITY CONTROL PROGRAM 8-5	
8.3.1 Organization 8-5	
8.3.2 Field Program Quality Control 8-5	
8.3.3 Quality Control Field Sample Results 8-6	
8.3.3.1 VOC Quality Control Results 8-6	
8.3.3.2 Semivolatile Organics and PUF Quality Control Results 8-7	
8.3.3.3 Quality Control Results - Metals 8-8	
8.3.3.4 Quality Control Results - TSP and PM ₁₀ 8-8	

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
8.3.4 Data Processing	8-8
8.4 ASSESSMENT OF DATA PRECISION AND COLLOCATED DUPLICATE SAMPLING RESULTS	8-10
8.5 QUALITY ASSURANCE FIELD PROCEDURES	8-12
8.5.1 System Audits	8-12
8.5.2 Performance Audits of Field Sampling Equipment	8-12
8.5.3 Calibration and Certification of Standards	8-13
9.0 CONCLUSIONS	9-1
9.1 TOTAL SUSPENDED PARTICULATES	9-1
9.2 RESPIRABLE PARTICULATES (PM-10)	9-2
9.3 METALS	9-2
9.4 ASBESTOS	9-3
9.5 VOLATILE ORGANIC COMPOUNDS	9-3
9.6 SEMI-VOLATILE ORGANIC COMPOUNDS	9-3
9.7 ORGANOCHLORINE PESTICIDES	9-4
9.8 CRITERIA POLLUTANTS	9-4
9.9 GENERAL INTERPRETATIONS	9-4
10.0 REFERENCES	10-1

TABLE OF CONTENTS (Continued)

LIST OF TABLES

TABLE 2.1-1	COLORADO AND NATIONAL AMBIENT AIR QUALITY STANDARDS
TABLE 2.2-1	SUMMARY OF TEMPERATURE DATA IN THE RMA VICINITY
TABLE 2.2-2	SUMMARY OF PRECIPITATION AND HUMIDITY DATA IN THE RMA VICINITY
TABLE 2.2-3	SUMMARY OF WIND AND PRESSURE DATA IN THE RMA VICINITY
TABLE 2.2-4	SUMMARY OF METEOROLOGICAL DATA IN THE RMA VICINITY
TABLE 3.2-1	SAMPLING LOCATIONS
TABLE 3.2-2	PARAMETER AND STRATEGIES FOR CMP AIR MONITORING PROGRAM - FY91
TABLE 3.2-3	SAMPLING STRATEGIES FOR HIGH EVENT AIR QUALITY MONITORING
TABLE 3.4-1	METEOROLOGICAL PARAMETERS MONITORED AT RMA DURING FY91
TABLE 3.5-1	RMA CONTINUOUS GASEOUS AIR MONITORING PROGRAM SUMMARY
TABLE 3.6-1	ANALYTICAL METHODS FOR AIR QUALITY MONITORING PROGRAM
TABLE 3.6-2	ANALYTES AND CERTIFIED REPORTING LIMITS FOR AIR QUALITY MONITORING PROGRAM
TABLE 4.1-1	BASIN F REMEDIATION PHASES
TABLE 4.1-2	EMISSION INVENTORY SUMMARY FOR REGULATED POLLUTANTS
TABLE 4.2-1	SUMMARY OF RMA TOTAL SUSPENDED PARTICULATES (TSP) MONITORING FOR FY91
TABLE 4.2-2	TOTAL SUSPENDED PARTICULATES (TSP) SAMPLING RESULTS FOR CMP FY91
TABLE 4.2-3	TOTAL SUSPENDED PARTICULATES (TSP) SAMPLING RESULTS FOR CMP PHASES 1-5
TABLE 4.2-4	TOTAL SUSPENDED PARTICULATES (TSP) SAMPLING RESULTS FOR BASIN F/IRA-F/RIFS PHASES 1-5
TABLE 4.2-5	COMBINED SEASONAL TSP CONCENTRATIONS FOR FY88 TO FY91
TABLE 4.2-6	SEASONAL TSP CONCENTRATIONS BY SITE

TABLE OF CONTENTS (Continued)

TABLE 4.2-7	PARTICULATE SOURCES WITH EMISSIONS OF 25 TPY OR MORE
TABLE 4.2-8	DENVER METROPOLITAN AREA TOTAL SUSPENDED PARTICULATES (TSP)
TABLE 4.3-1	SUMMARY OF RMA CMP FY91 SAMPLING FOR RESPIRABLE PARTICULATES OF LESS THAN 10 MICRONS (PM-10)
TABLE 4.3-2	CONCENTRATIONS OF RESPIRABLE PARTICULATES OF LESS THAN 10 MICRONS (PM-10) FOR CMP FY91
TABLE 4.3-3	CONCENTRATIONS OF RESPIRABLE PARTICULATES OF LESS THAN 10 MICRONS (PM-10) FOR PHASES 1-5
TABLE 4.3-4	COMBINED SEASONAL PM-10 CONCENTRATIONS
TABLE 4.3-5	SEASONAL PM-10 CONCENTRATIONS BY SITE
TABLE 4.3-6	CONCENTRATIONS OF RESPIRABLE PARTICULATES OF LESS THAN 10 MICRONS FOR PHASES 3, 4, AND 5 AT IRA-F SITES
TABLE 4.3-7	DENVER METROPOLITAN AREA RESPIRABLE PARTICULATES OF LESS THAN 10 MICRONS (PM-10)
TABLE 4.4-1	SUMMARY OF ROUTINE ICAP METALS SAMPLING FOR FY91
TABLE 4.4-2	SUMMARY OF CMP METALS CONCENTRATIONS FOR FY91
TABLE 4.4-3	SYNOPSIS OF FY91 HIGH EVENT MONITORING FOR METALS
TABLE 4.4-4	SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE
TABLE 4.4-5	METALS DATA SUMMARY FOR 1986-1987 REMEDIAL INVESTIGATION PROGRAM
TABLE 4.4-6	SUMMARY OF BASIN F/IRA-F/RIFS METALS CONCENTRATIONS FOR PHASES 1-5
TABLE 4.4-7	OBSERVED MAXIMUM METALS CONCENTRATIONS AND ASSOCIATED WIND SPEEDS AT CMP SITES
TABLE 4.4-8	SEASONAL METALS AND ARSENIC CONCENTRATIONS BY SITE
TABLE 4.4-9	MAXIMUM CONCENTRATIONS MEASURED AT RMA FOR CMP AND BASIN F/IRA-F CONCURRENT PROGRAMS
TABLE 4.4-10	RMA TARGET METALS COMPOUNDS COMPARISON TO HEALTH GUIDELINES
TABLE 4.5-1	SYNOPSIS OF FY91 ASBESTOS MONITORING

TABLE OF CONTENTS (Continued)

TABLE 4.6-1	SUMMARY OF ROUTINE VOLATILE ORGANIC COMPOUND (VOC) SAMPLING FOR FY91
TABLE 4.6-2	SYNOPSIS OF FY91 HIGH EVENT MONITORING FOR VOLATILE ORGANIC COMPOUNDS (VOC)
TABLE 4.6-3	SUMMARY OF FY91 CMP VOLATILE ORGANIC COMPOUND (VOC) CONCENTRATIONS
TABLE 4.6-4	SUMMARY OF FY91 IRA-F VOLATILE ORGANIC COMPOUND (VOC) CONCENTRATIONS
TABLE 4.6-5	SUMMARY OF CMP VOLATILE ORGANIC COMPOUNDS (VOC) CONCENTRATIONS FOR PHASES 1-5
TABLE 4.6-6	SUMMARY OF BASIN F/IRA-F/RIFS VOLATILE ORGANIC COMPOUNDS (VOC) CONCENTRATIONS FOR PHASES 1-5
TABLE 4.6-7	MAXIMUM CONCENTRATIONS AND LOCATIONS OF VOLATILE ORGANIC COMPOUNDS
TABLE 4.6-8	COMBINED SEASONAL AVERAGE VOC CONCENTRATIONS (FY88, FY89, FY90, AND FY91)
TABLE 4.6-9	VOLATILE ORGANIC COMPOUNDS (VOC) SOURCES WITH EMISSIONS GREATER THAN 10 TPY
TABLE 4.6-10	TOTAL POUNDS OF RELEASES OF TOXIC CHEMICALS BY FACILITY AND TOXICITY FOR DENVER AND ADAMS COUNTIES
TABLE 4.6-11	RELEASES OF TOXIC CHEMICALS FOR DENVER AND ADAMS COUNTIES
TABLE 4.6-12	RMA TARGET VOLATILE ORGANIC COMPOUNDS (VOC) COMPARISON TO HEALTH GUIDELINES FOR PHASES 1 AND 2
TABLE 4.6-13	RMA TARGET VOLATILE ORGANIC COMPOUNDS (VOC) COMPARISON TO HEALTH GUIDELINES FOR PHASES 3, 4 AND 5
TABLE 4.6-14	COMPARISON OF EPA AIR TOXIC STUDY AND RMA RESULTS FOR VOCs
TABLE 4.6-15	AMBIENT VOLATILE ORGANIC COMPOUNDS CONCENTRATIONS FROM VARIOUS STUDIES
TABLE 4.6-16	SUMMARY OF NONTARGET VOCs
TABLE 4.7-1	SUMMARY OF ROUTINE ORGANOCHLORINE PESTICIDE (OCP) SAMPLING FOR FY91
TABLE 4.7-2	SYNOPSIS OF FY91 HIGH EVENT MONITORING FOR ORGANOCHLORINE PESTICIDES (OCPS)

TABLE OF CONTENTS (Continued)

TABLE 4.7-3	SUMMARY OF CMP OCP CONCENTRATIONS FOR FY91 AT PERIMETER SITES
TABLE 4.7-4	SUMMARY OF CMP CONCENTRATIONS FOR FY91 AT BASIN F SITES
TABLE 4.7-5	SUMMARY OF CMP OCP PESTICIDE CONCENTRATIONS FOR FY91 DURING HIGH EVENT PERIODS
TABLE 4.7-6	SUMMARY OF CMP OCP PESTICIDE CONCENTRATIONS BY PHASE AT PERIMETER SITES
TABLE 4.7-7	SUMMARY OF CMP OCP PESTICIDE CONCENTRATIONS BY PHASE DURING HIGH EVEN PERIODS
TABLE 4.7-8	SUMMARY OF BASIN F/IRA-F ORGANOCHLORINE PESTICIDE (OCP) CONCENTRATIONS BY PHASE
TABLE 4.7-9	MAXIMUM AVERAGE LONG-TERM AND SHORT-TERM OCP CONCENTRATIONS
TABLE 4.7-10	ROCKY MOUNTAIN ARSENAL OCP CONCENTRATION COMPARISONS TO HEALTH GUIDELINES
TABLE 4.7-11	COMBINED SEASONAL OCP CONCENTRATIONS
TABLE 4.8-1	SYNOPSIS OF AIR STRIPPER OFF-GAS TESTING EFFORTS
TABLE 4.8-2	SUMMARY OF AVERAGE HNu AND OVA RESULTS (ppm) FOR AIR STRIPPER OFF-GAS TESTING
TABLE 4.8-3	AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION FOR SAMPLE DATE 2/28/91
TABLE 4.8-4	AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION FOR SAMPLE DATE 3/05/91
TABLE 4.8-5	AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION FOR SAMPLE DATE 3/11/91
TABLE 4.8-6	AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION FOR SAMPLE DATE 3/21/91
TABLE 4.8-7	AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION FOR SAMPLE DATE 3/27/91
TABLE 4.8-8	AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION FOR SAMPLE DATE 4/11/91
TABLE 4.9-1	RESULTS OF REAL-TIME BASIN F VENT AND CAP MONITORING
TABLE 5.1-1	RMA AND COLORADO DEPARTMENT OF HEALTH CONTINUOUS AIR QUALITY MONITORING SITES
TABLE 5.3-1	SUMMARY OF CARBON MONOXIDE 1-HOUR AVERAGE VALUES IN PPM, OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)

TABLE OF CONTENTS (Continued)

TABLE 5.3-2	SUMMARY OF CARBON MONOXIDE 8-HOUR AVERAGE VALUES IN PPM, OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)
TABLE 5.4-1	SUMMARY OF OZONE 1-HOUR AVERAGE VALUES IN PPM, OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)
TABLE 5.5-1	SUMMARY OF SULFUR DIOXIDE 1-HOUR AVERAGE VALUES IN PPM, OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)
TABLE 5.5-2	SUMMARY OF SULFUR DIOXIDE 3-HOUR AVERAGE VALUES IN PPM, OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)
TABLE 5.5-3	SUMMARY OF SULFUR DIOXIDE 24-HOUR AVERAGE VALUES IN PPM, OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)
TABLE 5.6-1	SUMMARY OF NITRIC OXIDE 1-HOUR AVERAGE VALUES IN PPM, OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)
TABLE 5.6-2	SUMMARY OF NITROGEN DIOXIDE 1-HOUR AVERAGE VALUES IN PPM, OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)
TABLE 5.6-3	SUMMARY OF NITROGEN OXIDES 1-HOUR AVERAGE VALUES IN PPM, OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)
TABLE 5.7-1	CARBON MONOXIDE (CO) SOURCES WITH EMISSIONS OF 100 TPY OR MORE
TABLE 5.7-2	SULFUR DIOXIDE (SO ₂) SOURCES WITH EMISSIONS OF 40 TPY OR MORE
TABLE 5.7-3	NITROGEN OXIDES (NO _x) SOURCES WITH EMISSIONS OF 40 TPY OR MORE
TABLE 5.7-4	RELEVANT AIR QUALITY AND METEOROLOGICAL DATA, FEBRUARY 2, 1991
TABLE 5.7-5	RELEVANT AIR QUALITY AND METEOROLOGICAL DATA, AUGUST 31, 1991
TABLE 6.1-1	SUMMARY OF HIGH WIND DUST EVENTS DURING FY91
TABLE 6.1-2	FEBRUARY 20, 1991, DUST EVENT DATA
TABLE 6.2-1	MARCH 19, 1991, BROWN CLOUD EVENT DATA
TABLE 7.1-1	SUMMARY OF RMA METEOROLOGICAL MONITORING DATA RECOVERY FOR FY91

TABLE OF CONTENTS (Continued)

TABLE 7.2-1	SUMMARY OF ROCKY MOUNTAIN ARSENAL MONTHLY METEOROLOGICAL CONDITIONS FOR FY91 (OCTOBER 1, 1990, THROUGH SEPTEMBER 30, 1991)
TABLE 7.4-1	FY89 - FY91 COMPARISON
TABLE 7.5-1	METEOROLOGICAL TOWER COMPARISON OF WIND SPEED (MPH)/DIRECTION (DEGREES)
TABLE 7.5-2	METEOROLOGICAL TOWER COMPARISON OF TEMPERATURE (°F) (FY91)
TABLE 7.5-3	METEOROLOGICAL TOWER COMPARISON OF PRECIPITATION (INCHES) (FY91)
TABLE 7.5-4	FREQUENCY (%) OF OCCURRENCE OF ATMOSPHERIC STABILITY CATEGORIES FOR EACH METEOROLOGICAL STATION (FY91)
TABLE 8.3-1	CMP TARGET VOLATILE ORGANIC COMPOUNDS (VOC) BLANK VALUES (in μg)
TABLE 8.3-2	SUMMARY OF OCP PERCENT RECOVERIES IN FIELD SPIKING EVENTS
TABLE 8.3-3	OCP BLANK VALUES (in μg)
TABLE 8.3-4	METALS BLANK VALUES (in μg)
TABLE 8.3-5	TSP-PM10 FIELD BLANK VALUES (in μg)
TABLE 8.4-1	COLLOCATED SAMPLE COMPARISONS FOR FY91
TABLE 8.4-2	CONTINUOUS AIR QUALITY PARAMETERS PRECISION RESULTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

- FIGURE 1.1-1 ROCKY MOUNTAIN ARSENAL LOCATION MAP
FIGURE 1.1-2 ROCKY MOUNTAIN ARSENAL REFERENCE MAP
FIGURE 1.2-1 CMP AIR QUALITY AND METEOROLOGICAL MONITORING STATIONS
FIGURE 2.2-1 STAPLETON AIRPORT WIND DIRECTION ROSE, 1982-1986
FIGURE 3.2-1 CMP AIR QUALITY MONITORING STATIONS AT ROCKY MOUNTAIN ARSENAL
FIGURE 3.2-2 NATIONAL AMBIENT AIR QUALITY SAMPLING SCHEDULE FOR 1991
FIGURE 3.3-1 LOCATION OF BASIN F AIR QUALITY MONITORING STATIONS ADDITIONS TO CMP
FIGURE 3.3-2 LOCATION OF IRA-F AIR QUALITY MONITORING STATIONS AT ROCKY MOUNTAIN ARSENAL
FIGURE 3.4-1 RMA METEOROLOGICAL MONITORING STATIONS
FIGURE 4.1-1 X/Q DISPERSION FOR PHASE 1
FIGURE 4.1-2 X/Q DISPERSION FOR PHASE 2-STAGE 1
FIGURE 4.1-3 X/Q DISPERSION FOR PHASE 2-STAGE 2
FIGURE 4.1-4 X/Q DISPERSION FOR PHASE 3
FIGURE 4.1-5 X/Q DISPERSION FOR PHASE 4
FIGURE 4.1-6 X/Q DISPERSION FOR PHASE 5
FIGURE 4.1-7 SOURCES OF REGULATED POLLUTANTS IN RMA VICINITY
FIGURE 4.2-1 CMP TOTAL SUSPENDED PARTICULATE RESULTS FOR FY91
FIGURE 4.2-2 TSP RESULTS AND X/Q DISPERSION FOR 9/09/91
FIGURE 4.2-3 TSP RESULTS AND X/Q DISPERSION FOR 3/19/91
FIGURE 4.2-4 TSP RESULTS AND X/Q DISPERSION FOR 9/27/91
FIGURE 4.2-5 TSP CONCENTRATIONS AT AQ10 DURING REMEDIAL AND POST-REMEDIAL PHASES
FIGURE 4.2-6 BASIN F/IRA-F TSP RESULTS BY REMEDIAL AND POST-REMEDIAL PHASE
FIGURE 4.2-7 COMPOSITE TSP ANALYSIS FOR PHASE 1
FIGURE 4.2-8 COMPOSITE TSP ANALYSIS FOR PHASE 5
FIGURE 4.2-9 GEOMETRIC MEAN TSP CONCENTRATION BY PHASE FOR EACH CMP SITE
FIGURE 4.2-10 COMPOSITE TSP ANALYSIS FOR 9/24/88
FIGURE 4.2-11 TSP RESULTS FOR 9/26/90

TABLE OF CONTENTS (Continued)

- FIGURE 4.2-12 SITE AQ11 TSP CONCENTRATIONS VS. HOURS OF WIND FROM DIRECTION OF BASIN F - PHASE 1
- FIGURE 4.2-13 SITE AQ11 TSP CONCENTRATION VS. HOURS OF WIND FROM DIRECTION OF BASIN F - PHASE 3
- FIGURE 4.2.14 PARTICULATE SOURCES WITH EMISSIONS OF 25 TPY OR MORE IN RMA VICINITY
- FIGURE 4.2-15 DENVER AREA TSP DATA FOR FY91 - GEOMETRIC MEANS
- FIGURE 4.3-1 RESULTS FOR FY91 AT CMP SITES
- FIGURE 4.3-2 PM-10 RESULTS AND X/Q DISPERSION FOR 2/05/91
- FIGURE 4.3-3 COMPARISON OF TSP AND PM-10 AT AQ2 DURING FY91
- FIGURE 4.3-4 COMPARISON OF TSP AND PM-10 AT AQ5 DURING FY91
- FIGURE 4.3-5 COMPARISON OF TSP AND PM-10 AT AQ9
- FIGURE 4.3-6 COMPOSITE PM-10 ANALYSIS FOR PHASE 1
- FIGURE 4.3-7 COMPOSITE PM-10 ANALYSIS FOR PHASE 5
- FIGURE 4.3-8 DENVER AREA PM-10 DATA FOR PHASE 5 ARITHMETIC MEANS
- FIGURE 4.4-1 METALS RESULTS AND X/Q DISPERSION FOR 3/19/91
- FIGURE 4.4-2 METALS RESULTS AND X/Q DISPERSION FOR 3/25/91
- FIGURE 4.4-3 METALS RESULTS AND X/Q DISPERSION FOR 7/02/91
- FIGURE 4.4-4 CHROMIUM RESULTS BY PHASE
- FIGURE 4.4-5 COPPER RESULTS BY PHASE
- FIGURE 4.4-6 MERCURY RESULTS BY PHASE
- FIGURE 4.4-7 ZINC RESULTS BY PHASE
- FIGURE 4.4-8 LEAD RESULTS BY PHASE
- FIGURE 4.4-9 ARSENIC RESULTS BY PHASE
- FIGURE 4.4-10 CADMIUM RESULTS BY PHASE
- FIGURE 4.4-11 X/Q DISPERSION AND BASIN F METALS FOR 9/6/88
- FIGURE 4.4-12 X/Q DISPERSION AND IRA-F METALS FOR 9/10/90
- FIGURE 4.4-13 COMPOSITE METALS ANALYSIS FOR PHASE 1 - ANNUAL AVERAGE VALUES
- FIGURE 4.4-13A COMPOSITE METALS ANALYSIS FOR PHASE 1 - 24 HOUR MAXIMUM VALUES
- FIGURE 4.4-14 COMPOSITE METALS ANALYSIS FOR PHASE 5 - ANNUAL AVERAGE VALUES
- FIGURE 4.4-14A COMPOSITE METALS ANALYSIS FOR PHASE 5 - 24 HOUR MAXIMUM VALUES
- FIGURE 4.6-1 VOC RESULTS AND X/Q DISPERSION FOR 6/12/91
- FIGURE 4.6-2 VOC RESULTS AND X/Q DISPERSION FOR 6/20/91
- FIGURE 4.6-3 VOC RESULTS AND X/Q DISPERSION FOR 6/26/91

TABLE OF CONTENTS (Continued)

FIGURE 4.6-4	BICYCLOHEPTADIENE RESULTS BY PHASE
FIGURE 4.6-5	CHLOROFORM RESULTS BY PHASE
FIGURE 4.6-6	DICYCLOPENTADIENE RESULTS BY PHASE
FIGURE 4.6-7	DIMETHYL DISULFIDE RESULTS BY PHASE
FIGURE 4.6-8	TOLUENE RESULTS BY PHASE
FIGURE 4.6-9	X/Q DISPERSION AND BASIN F VOCs FOR 8/12/88
FIGURE 4.6-10	X/Q DISPERSION AND IRA-F VOCs FOR 7/28/90
FIGURE 4.6-11	COMPOSITE VOC ANALYSIS FOR PHASE 1 - ANNUAL AVERAGE VALUES
FIGURE 4.6-11A	COMPOSITE VOC ANALYSIS FOR PHASE 5 - 24 HOUR MAXIMUM VALUES
FIGURE 4.6.12	COMPOSITE VOC ANALYSIS FOR PHASE 5 - 24 HOUR AVERAGE VALUES
FIGURE 4.6-12A	COMPOSITE VOC ANALYSIS FOR PHASE 5 - 24 HOUR MAXIMUM VALUES
FIGURE 4.6-13	VOC SOURCES WITH EMISSIONS OF 25 TPY OR MORE IN RMA VICINITY
FIGURE 4.7-1	OCP RESULTS AND X/Q DISPERSION FOR 6/12/91
FIGURE 4.7-2	OCP RESULTS AND X/Q DISPERSION FOR 6/20/91
FIGURE 4.7-3	OCP RESULTS AND X/Q DISPERSION FOR 6/26/91
FIGURE 4.7-4	ALDRIN BY PHASE
FIGURE 4.7-5	CHLORDANE BY PHASE
FIGURE 4.7-6	DIELDRIN BY PHASE
FIGURE 4.7-7	ENDRIN BY PHASE
FIGURE 4.7-8	ISODRIN BY PHASE
FIGURE 4.7-9	X/Q DISPERSION AND BASIN F PESTICIDES FOR 8/23/88
FIGURE 4.7-10	X/Q DISPERSION AND IRA-F PESTICIDES FOR 9/8/90
FIGURE 4.7-11	COMPOSITE OCP ANALYSIS FOR PHASE 1 - ANNUAL AVERAGE VALUES
FIGURE 4.7-11A	COMPOSITE OCP ANALYSIS FOR PHASE 1 - 24 HOUR MAXIMUM VALUES
FIGURE 4.7-12	COMPOSITE OCP ANALYSIS FOR PHASE 5
FIGURE 4.8-1	AIR STRIPPER OFF-GAS FLOW DIAGRAM AND SAMPLING LOCATIONS (2/21/91, 2/28/91, 3/5/91, 3/11/91)
FIGURE 4.8-2	AIR STRIPPER OFF-GAS FLOW DIAGRAM AND SAMPLING LOCATIONS (3/21/91, 3/27/91, 4/4/91, 4/11/91)
FIGURE 4.9-1	LOCATIONS OF WASTE PILE VENTS AND SANDBAGS FOR REAL-TIME MONITORING
FIGURE 4.9-2	LOCATION OF TANK FARM, PONDS A AND B, WASTE PILE AND RESTORED BASIN F

TABLE OF CONTENTS (Continued)

- FIGURE 5.1-1 RMA AND COLORADO DEPARTMENT OF HEALTH
CONTINUOUS AIR QUALITY MONITORING SITES
- FIGURE 5.3-1 RMA CMP MONTHLY MEAN FOR CARBON MONOXIDE
MAY 1989 - SEPTEMBER 1991
- FIGURE 5.3-2 RMA CMP FY91 DIURNAL CYCLE FOR CARBON
MONOXIDE
- FIGURE 5.3-3 CMP VERSUS CDH CONCENTRATION, 1 HOUR
MAXIMUM CARBON MONOXIDE
- FIGURE 5.3-4 CMP VERSUS CDH CONCENTRATION, 8 HOUR
MAXIMUM CARBON MONOXIDE
- FIGURE 5.4-1 RMA CMP MONTHLY MEAN FOR OZONE, MAY 1989 -
SEPTEMBER 1991
- FIGURE 5.4-2 RMA CMP FY91 DIURNAL CYCLE FOR OZONE
- FIGURE 5.4-3 CMP VERSUS CDH CONCENTRATION 1 HOUR
MAXIMUM OZONE
- FIGURE 5.5-1 RMA CMP MONTHLY MEAN FOR SULFUR DIOXIDE,
MAY 1989 - SEPTEMBER 1991
- FIGURE 5.5-2 RMA CMP FY91 DIURNAL CYCLE FOR SULFUR
DIOXIDE
- FIGURE 5.5-3 CMP VERSUS CDH CONCENTRATION, 3 HOUR
MAXIMUM SULFUR DIOXIDE
- FIGURE 5.5-4 CMP VERSUS CDH CONCENTRATION, 24 HOUR
MAXIMUM SULFUR DIOXIDE
- FIGURE 5.6-1 RMA CMP FY91 MONTHLY MEAN FOR NITRIC OXIDE,
MAY 1989 - SEPTEMBER 1991
- FIGURE 5.6-2 RMA CMP FY91 MONTHLY MEAN FOR NITROGEN
OXIDES, MAY 1989 - SEPTEMBER 1991
- FIGURE 5.6-3 RMA CMP FY91 MONTHLY MEAN FOR NITROGEN
DIOXIDE, MAY 1989 - SEPTEMBER 1991
- FIGURE 5.6-4 RMA CMP RMA CMP FY91 DIURNAL CYCLE FOR
NITROGEN OXIDES
- FIGURE 5.6-5 CMP VERSUS CDH CONCENTRATION, 24-HOUR
MAXIMUM, NITROGEN DIOXIDE
- FIGURE 5.7-1 SOURCES OF REGULATED POLLUTANTS IN RMA
VICINITY
- FIGURE 6.1-1 DUST EVENT: FEBRUARY 20, 1991
- FIGURE 6.1-2 FEBRUARY 20, 1991 DUST EVENT DAILY
METEOROLOGICAL AND NO_x GASEOUS DATA
- FIGURE 6.2-1 BROWN CLOUD EVENTS: MARCH 19, 1991

TABLE OF CONTENTS (Continued)

- FIGURE 6.2-2 MARCH 19, 1991 DUST EVENT DAILY METEOROLOGICAL AND NO_x GASEOUS DATA
- FIGURE 7.2-1 WIND ROSE RMA FALL (FY91) VS. STAPLETON FALL (86-90)
- FIGURE 7.2-2 WIND ROSE RMA WINTER (FY91) VS. STAPLETON WINTER (86-90)
- FIGURE 7.2-3 WIND ROSE RMA SPRING (FY91) VS. STAPLETON SPRING (86-90)
- FIGURE 7.2-4 WIND ROSE RMA SUMMER (FY91) VS. STAPLETON SUMMER (86-90)
- FIGURE 7.2-5 WIND ROSE RMA ANNUAL (FY91) VS. STAPLETON ANNUAL (86-90)
- FIGURE 7.3-1 DIURNAL WIND ROSE RMA (FALL FY91) VS. DIURNAL STAPLETON (FALL 86-90)
- FIGURE 7.3-2 DIURNAL WIND ROSE RMA (WINTER FY91) VS. DIURNAL STAPLETON (WINTER 86-90)
- FIGURE 7.3-3 DIURNAL WIND ROSE RMA (SPRING FY91) VS. DIURNAL STAPLETON (SPRING 86-90)
- FIGURE 7.3-4 DIURNAL WIND ROSE RMA (SUMMER FY91) VS. DIURNAL STAPLETON (SUMMER 86-90)
- FIGURE 7.3.5 DIURNAL WIND ROSE RMA (ANNUAL FY91) VS. DIURNAL STAPLETON (ANNUAL 86-90)

TABLE OF CONTENTS (Concluded)

LIST OF APPENDIXES

APPENDIX A	TOTAL SUSPENDED PARTICULATES (TSP) DATA
APPENDIX B	RESPIRABLE PARTICULATES OF LESS THAN 10 MICRONS (PM-10)
APPENDIX C	ARSENIC, METALS AND MERCURY DATA
APPENDIX D	ASBESTOS DATA
APPENDIX E	VOLATILE ORGANIC COMPOUNDS (VOC) DATA
APPENDIX F	ORGANOCHLORINE PESTICIDES (OCP) DATA
APPENDIX G	QUALITY ASSURANCE/QUALITY CONTROL
APPENDIX H	CONTINUOUS AIR QUALITY DATA
APPENDIX I	METEOROLOGICAL DATA AND JOINT FREQUENCY DISTRIBUTION

ACRONYMS AND ABBREVIATIONS

111TCE	1,1,1-Trichloroethane
112TCE	1, 1,2-Trichloroethane
ACGIH	American Council of Governmental Industrial Hygienists
ADI	Acceptable Daily Intake
Atrazine	2-chloro-4-ethylamino-6-isopropylamino-s-trianine
BCHPD	Bicycloheptadiene
CAQMM	Comprehensive Air Quality and Meteorological Monitoring Program
C ₆ H ₆	Benzene
CCl ₄	Carbon Tetrachloride
CCM	Cubic Centimeters per Minute
CDH	Colorado Department of Health
CFM	Cubic Feet per Minute
CH ₂ Cl ₂	Methylene Chloride
CHCl ₃	Chloroform
Chlordane	1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-IH-indene
ClC ₆ H ₅	Chlorobenzene
CMP FY90	Comprehensive Monitoring Program Fiscal Year 1990
CO	Carbon Monoxide
CRL	Certified Reporting Limit
CVAAS	Cold Vapor Atomic Absorption Spectroscopy
DBCP	Dibromochloropropane
DCLE11	1,1-Dichloroethane
DCLE12	1,2-Dichloroethane
DCPD	Dicyclopentadiene
DDD	Dichlorodiphenyldichloroethane
DIMP	Diisopropylmethyl phosphonate
DMB12	Dimethylbenzene
DMDS	Dimethyl Disulfide
DMMP	Dimethylmethyl phosphate
EPA	Environmental Protection Agency
ETC ₆ H ₅	Ethylbenzene
GC/MS	Gas Chromatography/Mass Spectrometry
GC/ECD	Gas Chromatography/Electron Capture Detection
HEAST	Health Effects Assessment Summary Table
ICAP/ICP	Inductively Coupled Argon Plasma
IRA-F	Interim Response Action at Basin F
IRDMS	Installation Restoration Data Management System
IRIS	Integrated Risk Information System
ISC	Industrial Source Complex Dispersion Model

Malathion	0,0-dimethyl-s-(1,2-dicarboxyethyl) phosphorodithioate
MEC ₆ H ₅	Toluene
MIBK	Methyl Isobutyl Ketone
MRI	Midwest Research Institute
MST	Mountain Standard Time
NAAQS	National Ambient Air Quality Standards
NATICH	National Air Toxics Information Clearinghouse
NIOSH	National Institute of Occupational Safety and Health
NNDMEA	N-Nitrosodimethylamine
NO	Nitric Oxide
NO ₂	Nitrogen Dioxide
NO _x	Nitrogen Oxides
O ₃	Ozone
OCP	Organochlorine Pesticides
Parathion	Parathion (C ₁₀ H ₁₄ NO ₅ PS)
PMRMA	Program Manager Rocky Mountain Arsenal
PM-10/PM ₁₀	Respirable Particulates less than 10 microns
PPDDE	Dichlorodiphenylethane
PPDDT	Dichlorodiphenyltrichloroethane
PSD	Prevention of Significant Deterioration
PUF	Polyurethane Foam
QA	Quality Assurance
QC	Quality Control
RBACs	Risk-Based Air Concentrations
RfCs	Reference Concentrations
RMA	Rocky Mountain Arsenal
SARA	Superfund Amendments and Reauthorization Act
SCCM	Standard Cubic Centimeters per Minute
SCFM	Standard Cubic Feet per Minute
SO ₂	Sulfur Dioxide
Supona	2-chloro-1-(2,4-dichlorophenyl) vinyl diethyl phosphate
SVOC	Semi-Volatile Organic Compounds
T12DCE	Trans-1,2-Dichloroethene
TCLEE	Tetrachloroethene
TIC	Tentatively Identified Compound
TLV	Threshold limit value
tpy	tons per year
TRCLE	Trichloroethene
TSP	Total Suspended Particulates
UCRL	Upper Certified Reporting Limit
UNK	Unknown number
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USAEEHA	U.S. Army Environmental Hygiene Agency

VOC
XYLENE

Volatile Organic Compounds
Xylene

4.0

RESULTS OF FY91 PROGRAM

4.1 BASIS OF AIR QUALITY DATA EVALUATION

The purpose of the Air Monitoring Task of the CMP is to maintain a baseline database to verify ambient air quality at RMA and to evaluate progress made in current and future remedial actions. The program has several related key objectives:

- Evaluate potential air quality health hazards that may exist within the RMA boundaries
- Confirm progress made to date in removing potential air contaminants resulting from previous activities
- Provide standardized procedures of data collection to measure impacts of ongoing remedial activities
- Describe potential impacts of other sources of air pollutants

The data monitoring, verification, and evaluation programs have been designed to achieve these objectives. Additionally, the data analyses have been related to the source of contaminants detected. Source attribution requires consideration of a number of variables unique to air quality assessment:

- Source and receptor specific meteorological conditions including wind direction, wind speed, atmospheric stability, mixing height, temperature, and precipitation
- RMA land disturbances: in particular, remedial construction and excavation activities
- Source environment including topography, soil types, and vegetation

- Ambient air quality concentration levels directly upwind from the RMA area, including metropolitan Denver

In summary, measured background levels of TSP, PM₁₀, metals, VOC, SVOC, and asbestos within RMA cannot be evaluated in terms of the stated objectives without identifying causative and contributing factors including off-Arsenal sources. Thus, a computer database of ambient air quality concentrations, meteorological data, and significant influencing parameters such as local air contaminant sources, has been established and maintained during the CMP. As the database is expanded over several years, the statistical significance and additional applications of the database may increase. For example, the cumulative effect of previous remedial activities should indicate decreasing concentration levels in the vicinity of RMA. If contaminant levels are above normal background values, a persistence of a given element and/or an indication of the ineffectiveness of remedial actions would be confirmed. Additional or alternate mitigating actions may be required.

During FY91, a full year of data was collected in the vicinity of Basin F under the CMP. In this report, these post-remedial data are compared with data collected at identical monitoring sites under similar meteorological and climatological conditions during the Basin F remediation period. The basis of this evaluation is discussed further in Section 4.1.2.

4.1.1 Computerized Documentation

Computerized documentation and analysis have provided the following information for this Air Quality Data Assessment Report:

- For each sampling station, a list including the compounds detected at that station, the range of concentrations reported, the maximum concentration, pertinent weather conditions, and other factors such as mitigation through remedial activity. High event monitoring activity were similarly documented and reported.

- Comparison of measured TSP, PM₁₀, metals, arsenic, mercury, asbestos, VOCs, and OCPs with available regional data and with regulatory guidelines, threshold limit values (TLV), and other air toxic guidelines as appropriate. Comparisons with standards and guidelines are discussed further in this section for each specific group of analytes.
- Comparison of significant (high or low) contaminant levels under similar conditions to indicate remedial progress. For example, VOC and OCP values at an RMA site over a particular season could result from remedial activity, transport from outside the Arsenal, or specific meteorological conditions. Similarly, high metals levels could result from strong wind speeds from a persistent direction, transport from the metropolitan area, significant excavation activities, or all of the above concurrently. The database compiled over the life of the CMP delineates these relationships for this and future reports.
- Identification of meteorological conditions, excavation activities, or discrete sources and influences that may trigger high levels of contaminant activity and require special precautions and mitigating actions.

In addition, this CMP Air Quality Data Assessment Report for FY91 provides, for the purpose of remediation assessment, the results of the Interim Action Basin F Cleanup Program from the initiation of remedial activities at Basin F in 1988, through September 30, 1991. Evaluation of those data includes the use of the following organizational strategies:

- Incorporation of all remedial activity monitoring data into the CMP, and assessment of these data as a subset of the overall database
- Specific standardized guidelines and criteria for air monitoring support of excavation and remedial activities at RMA. Criteria have been based on available literature, existing state-of-the-art techniques, and direct FY88, FY89, FY90, and FY91 experience with air quality monitoring and contaminants of concern at RMA; guidelines include specific

instrumentation, monitoring procedures and techniques, real-time prediction and alert procedures, and models relating to Health and Safety.

4.1.2 Remediation Evaluation

During the CMP FY88 and FY89 periods, Basin F remediation proceeded from March 22, 1988, to May 4, 1989. The post remediation period from May 5, 1989, to September 30, 1989, has continued through the conclusion of CMP FY91. The CMP Basin F Remediation Monitoring Program and follow-on IRA-F data provide result of potential air contaminant levels prior to, during, and subsequent to the remediation program. These data reflect remedial progress. The results of this assessment are provided in this report under the phases and stages shown in Table 4.1-1. All data shown in tables and figures for FY91 cover the period from October 1, 1990, through September 30, 1991.

4.1.3 Dispersion Model Applications

The CMP/Basin F Air Quality Modeling Programs included the development and/or application of several standards and special purpose models for assessing potential contaminant impacts, including the Industrial Source Complex (ISC) Model and a PUFF advection model (USEPA 1986). Dispersion modeling assisted appreciably in addressing impacts from potential emission sources, both on and off the Arsenal. During FY88 and FY89, dispersion modeling was employed to evaluate CMP-monitored data at Basin F, the South Plants, and Basin A. Both the ISC and PUFF Model were also used effectively in the Basin F cleanup program to assess real-time contamination levels during remedial activities and to provide a forewarning of potential hazardous conditions.

The FY91 Report provides a joint analysis of CMP and Basin F data over a 43-month period to evaluate remedial impacts and post-remedial progress. Dispersion models were used to identify potential source impacts and overriding meteorological influences. The objective was to confirm that concentrations measured under the remedial phase periods occurred during typical meteorological factors. Figures 4.1-1 through 4.1-6 show mean dispersion patterns for the Phase 1, the Phase 2 Stage 1, and Phase 2 Stage 2

remediation periods, and the Phase 3, 4, and 5 post-remediation periods for an area source centered at Basin F. These dispersion patterns influence sampling results for the CMP and Basin F parameters measured during the remediation assessment periods.

The dispersion patterns are depicted by relating ambient concentration (X), to source strength (Q) by incorporating site specific meteorological factors without source measurements. The X/Q contours were obtained from the EPA ISC Model (using Basin F as a hypothetical area source); they reflect the influences of wind speed, wind direction, atmospheric stability, and inversion conditions on the spread of pollutants for the monitoring period for each phase. The X/Q values do not indicate actual ambient concentrations, but indicate relative strength, or potential for concentration levels, based on meteorological conditions and a unitized (1 gram per second) source strength. Higher measured ambient concentration levels correspond to higher X/Q values when there is a significant source impact. During Phases 1 and 2, higher X/Q values are found close to the Basin F source and directly downwind from prevailing winds. The dispersion patterns are also skewed to the north of Basin F, reflecting the prevailing flow during the monitoring periods, as shown in the wind rose insert for each figure. Thus, higher ambient concentrations as a result of potential Basin F source contaminants during remediation activities are probably located adjacent to and north of Basin F. Monitoring results for FY88 and FY89 during remediation activity substantiated the modeling.

Dispersion patterns are similar during Phase 3, 4, and 5 periods, although there were seasonal variations. The dispersion patterns, in fact, were closely identical for each phase of the remediation and post-remediation periods. The implication, therefore, is that the dispersion characteristics defined by the measured meteorology were similar during the 5 phases. Therefore, any significant variations in monitoring are a function of source emissions. For example, high pesticide levels were noted during the Phase 1 period. During Phase 2, Phase 3, Phase 4, and Phase 5, these contaminant levels decreased significantly (under similar dispersion conditions), implying that the potential Basin F emissions sources for these compounds were effectively contained at the conclusion of the Phase 1 period.

4.1.4 Source Emission Factors

One objective of the air quality assessment is to identify emission sources that contribute to ambient air levels measured by the RMA monitoring program. The CMP demonstrated that Basin F was a potential source of several VOC, SVOC, and metals compounds associated with the remedial programs during FY88. High TSP levels were also evident at Basin F as a result of intense remedial construction activity. Significant decreases in ambient levels for most of these compounds occurred during Phases 3, 4, and 5 post-remediation, reflecting decreased emissions from Basin F and the associated remedial program.

As Basin F emissions decrease, other RMA sources could come into focus, such as Basin A, the South Plants, the Hydrazine Plant, and localized construction activities. These sources, as of the FY91 data collection period, appear to be at lower levels of intensity, and in most cases their impacts are comparable to VOC, OCP, and metals levels measured in the urban environment of metropolitan Denver. CMP monitoring results are difficult to evaluate for most pollutants measured during FY91 without examining the potential emission sources across the Denver urban area.

A number of mobile and stationary sources in metropolitan Denver may impact CMP air quality monitoring sites, depending upon temperature, wind direction, inversion conditions, and other meteorological factors influencing the Denver area. This report further identifies these external conditions and sources. Table 4.1-2 and Figure 4.1-7 show selected sources in metropolitan Denver that may influence RMA air quality under certain meteorological conditions. Several investigations relating RMA baseline air quality levels with off-Arsenal sources are discussed in various sections of this report. In addition, a study relating RMA gaseous monitoring data under various visibility conditions, including Denver "brown cloud" episodes is provided in Section 6.0.

The following sections provide specific monitoring results and data evaluation for all parameters collected during the FY88 through FY91 programs.

TABLE 4.1-1
BASIN F REMEDIATION PHASES

Phase	Dates	Activity	Monitoring Data Available
1	3/22/88 - 12/12/88	Basin F clean-up. Stockpiling of clay for future capping of basin.	CMP FY88, CMP FY89, Basin F Remediation Monitoring Program, RIFS Odor Program
2	(Stage 1) 12/13/88 - 2/15/89 (Stage 2) 2/16/89- 6/6/89	Capping of basin with clay. Capping of basin with topsoil. Grading and reseeding of basin and surrounding area. Liner installed over holding pond.	CMP FY89, Basin F Remediation Monitoring Program, RIFS Odor Program
3	5/6/89 - 9/30/89	Post-remedial period: Pumping of accumulated waste pile liquids to holding pond.	CMP FY89, IRA-F FY89
4	10/1/89 - 9/30/90	Post remedial period.	CMP FY90, IRA-F FY90
5	10/1/90 - 9/30/91	Post-remedial period	CMP* FY91

* CMP is an integration of the CMP and IRA-F monitoring programs designated during the previous monitoring fiscal years.

TABLE 4.1-2
EMISSION INVENTORY SUMMARY
FOR REGULATED POLLUTANTS
(IN TONS PER YEAR)

Facility	Map #	Part. ¹	NO _x ²	SO ₂ ³	VOC ⁴	CO ⁵
PSCO Cherokee Plant	1	238	17,025	12,340	63	57
PSCO Arapahoe Plant	2	127	5,629	4,112	19	160
Colo. Interstate Gas (Wat.)	3		718		29	165
Conoco Refining, Inc.	4	141	634	2,504	746	788
Koch Hydrocarbon Co. (1)	5		569		13	84
Amoco Production Co. (Wat.)	6		409		31	51
Colorado Refining Co.	7		365	1,041	971	788
PSCO Zuni Plant	8		213			16
Wyco Pipeline	9				204	
Rainbo Bread Co.	10				31	
Sinclair Marketing	11				354	
Mastercraft (1)	12				125	7
AT&T Information Systems	13				54	
Chase Terminal	14				83	
Littleton/Englewood	15*			262		
Amoco Production Co. (Byrs.)	16*		373		9	48
Gates Rubber Co.	17		266	76		28
Metro Denver Sewage Disposal	18		110		25	128
Western Paving Co.	19			26		8
U.S. West	20			8		24
Amoco Production (3rd Ctr.)	21		107			14
Asarco Inc.	22					
Ralston Purina	23	98		51		3
U.S.A.F. Buckley Air Base	24	28	290	39	19	55
Diamond Shamrock Corp.	25				96	
Sunstrand Aviation Operation	26					
Pillow Kingdom Co. (Kearney)	27				239	
Samsonite Corp.	28					3
Whirlpool Kitchens Inc.	29					
Shafer Commercial Seating Co.	30				99	
Mesa Fiberglass Co.	31					
Alltac Corporation	32				118	
Pillow Kingdom Co. (2)	33				99	
W.J. Whatley Co.	34				17	
Stanley Aviation Corp.	35				15	
Redfield RifleScope Co.	36				16	
Chemrex Inc.	37					
Vessel Gas Processing Co.	38					
Gulf Energy Development	39		96			7

TABLE 4.1-2
(Concluded)

Facility	Map #	Part. ¹	NO _x ²	SO ₂ ³	VOC ⁴	CO ⁵
Oil & Solvent Processing Co.	40				47	
Scotts Liquid Gold Co.	41				48	
Advance Foam Plastics Inc.	42				96	
Verticel Co.	43					
Republic Paper Co.	44			54		4
Benjamin Moore Paint Co.	45				83	
Mastercraft (2)	46					
Koch Hydrocarbon Co. (AdmCty)	47		66	2		6
Brannan Sand & Gravel Co.	48	27		16	17	19
Zignan Sand & Gravel Co.	49					
Sun Gas Dragoon Compress.	50				4	14
Bijou Recycling	51					
Colo. Interstate Gas (Arap.)	52		145			27
Phillips Pipeline Co.	53				81	
Rocky Mountain Arsenal	54	1.2	25.2	5.4	1.9	7.3

Sources: Colorado Department of Health EISPS Inventory, May 1990 and 1992.

* Annual pollutant emissions based on 1989 data (as presented in FY90 data report)

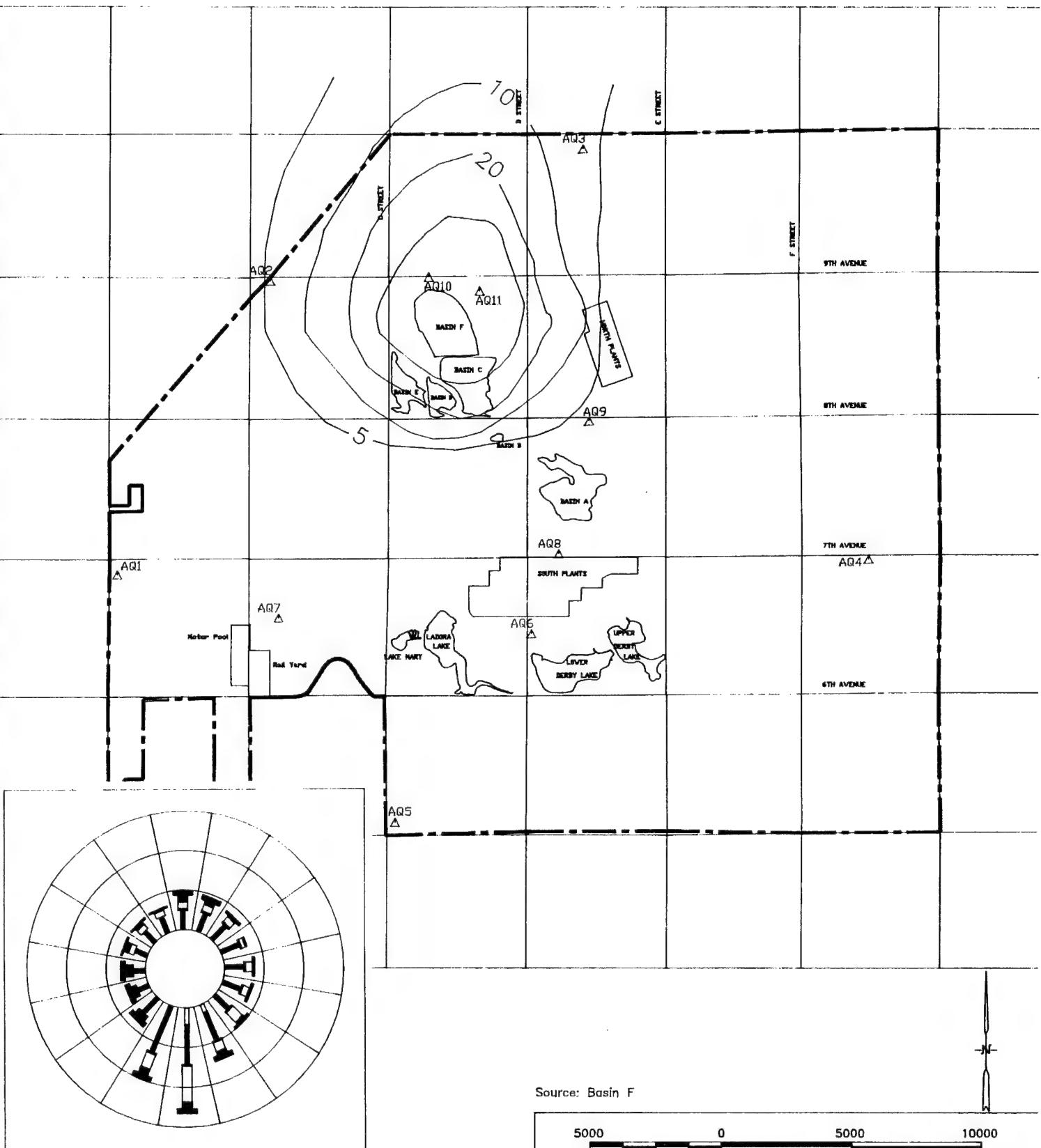
¹ A blank entry indicates that either total annual emissions for 1991 were less than 25 tons or did not report quantifiable annual emissions during 1989 (as presented in FY90 data report).

² A blank entry indicates that either total annual emissions for 1991 were less than 50 tons or did not report quantifiable annual emissions during 1989 (as presented in FY90 data report).

³ Annual emission totals exceeding 1,000 tons are based on 1991 data; annual emissions totals less than 1,000 tons or blank entries are based on 1989 data (as presented in FY90 data report).

⁴ A blank entry indicates that either total annual emissions for 1991 were less than 11 tons or did not report quantifiable annual emissions during 1989 (as presented in FY90 data report).

⁵ Annual emission totals exceeding 100 tons are based on 1991 data; annual emission totals less than 100 tons or blank entries are based on 1989 data (as presented in FY90 data report).



AQ5
△

Comprehensive Monitoring Location

Source: Basin F

5000 0 5000 10000
SCALE Feet



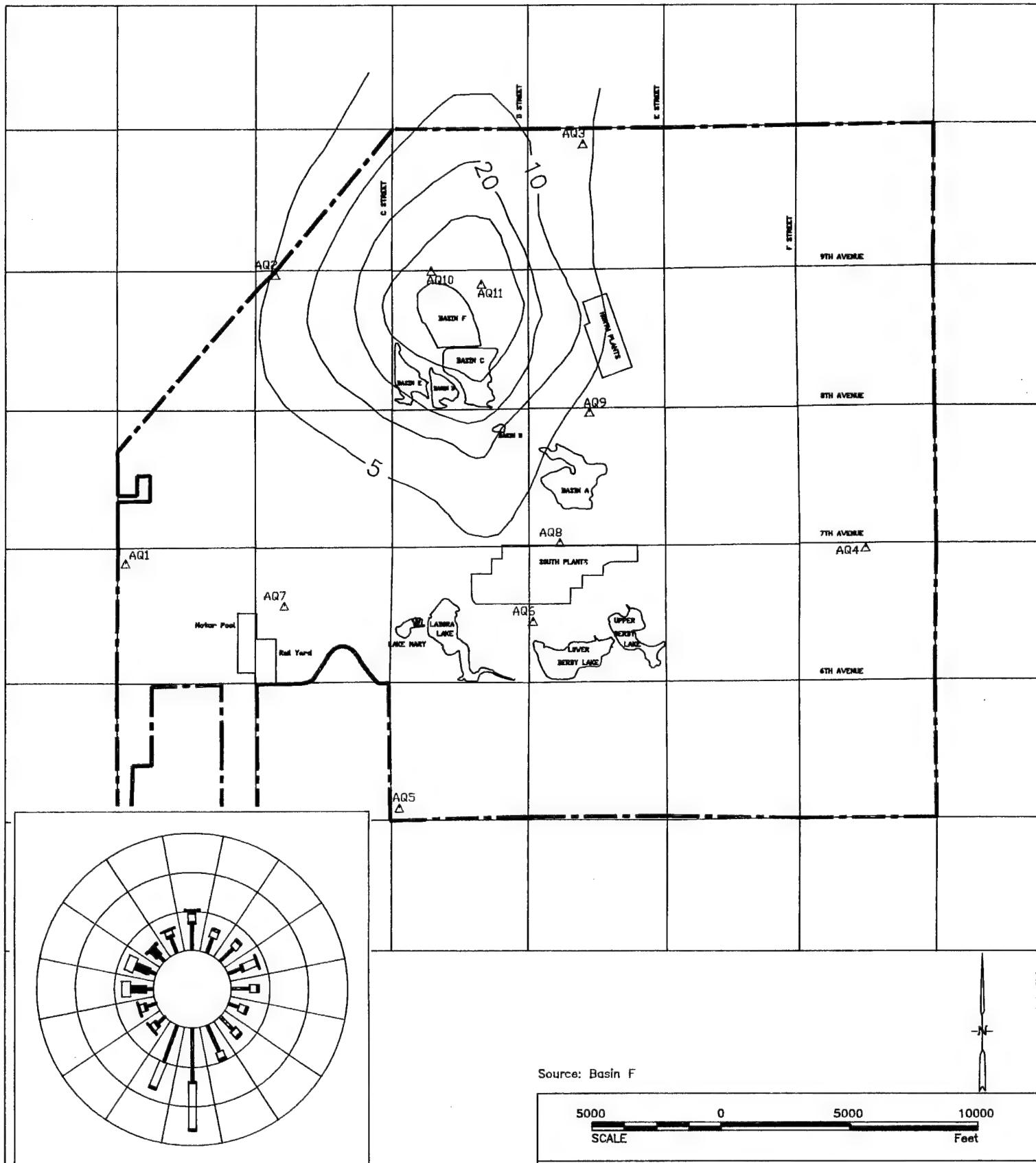
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

x/Q Dispersion for Phase 1 CMP Air Quality Data

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb	DATE : 8/4/92	PROJECT NO: 22787E	FIG. NO : 4.1-1
CHKD BY : .	DATE : .		



AQ5 Δ Comprehensive Monitoring Location

Source: Basin F

5000 0 5000 10000
SCALE Feet



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

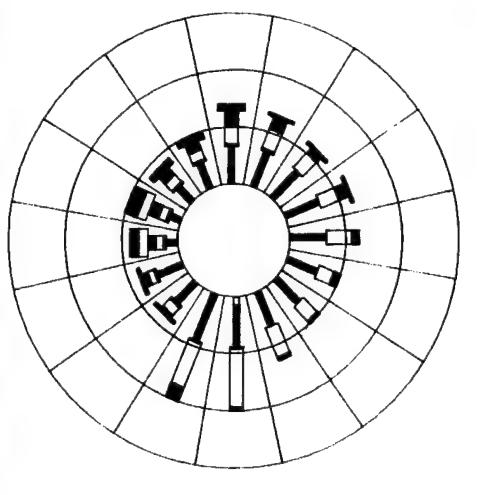
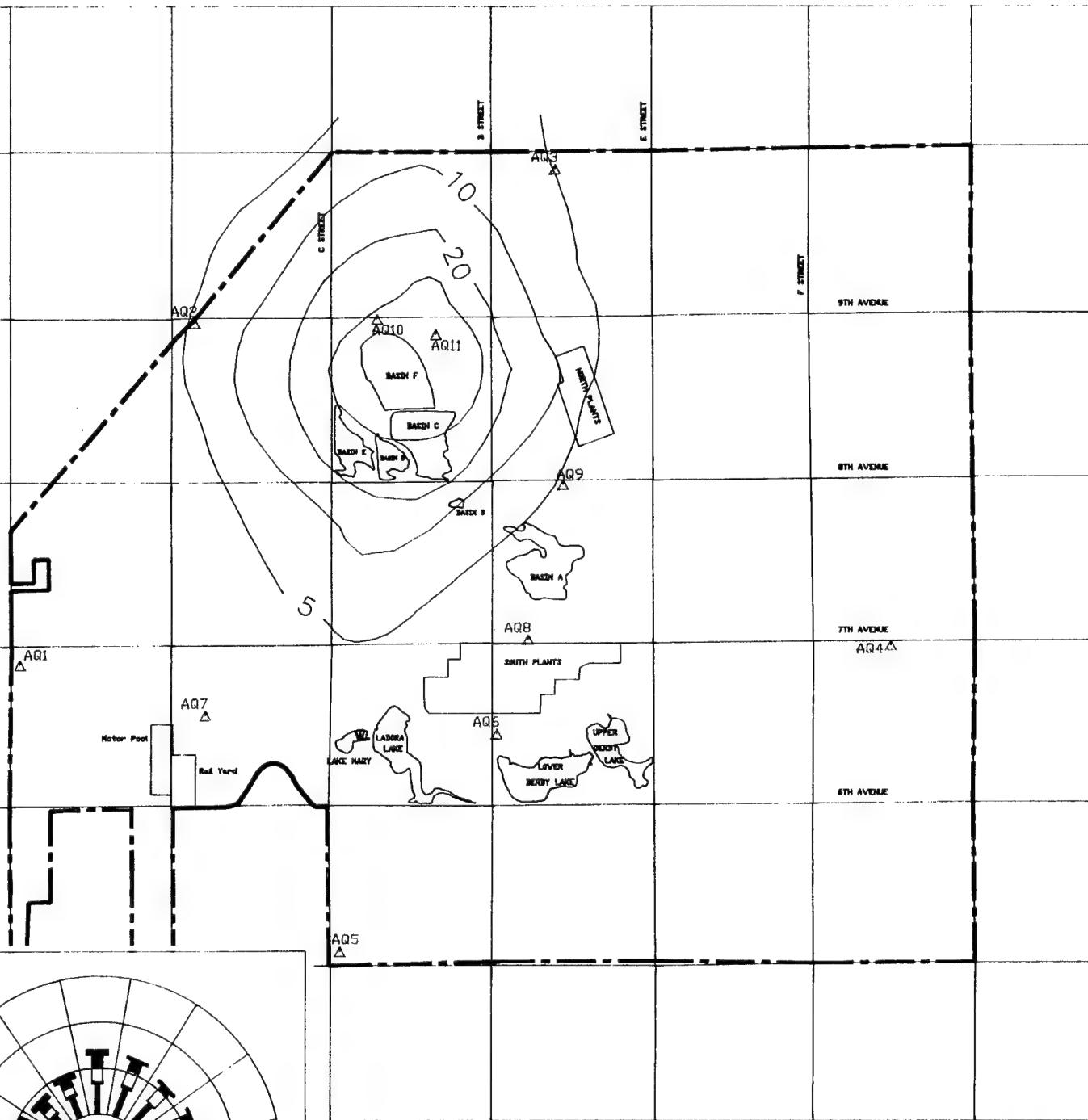
x/Q Dispersion for Phase 2 – Stage 1 CMP Air Quality Data

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb	DATE : 8/4/92
CHKD BY : .	DATE : .

PROJECT NO: 22787E	FIG. NO : 4.1-2
--------------------	-----------------



AQ5 Comprehensive Monitoring Location

Source: Basin F

5000 0 5000 10000
SCALE Feet



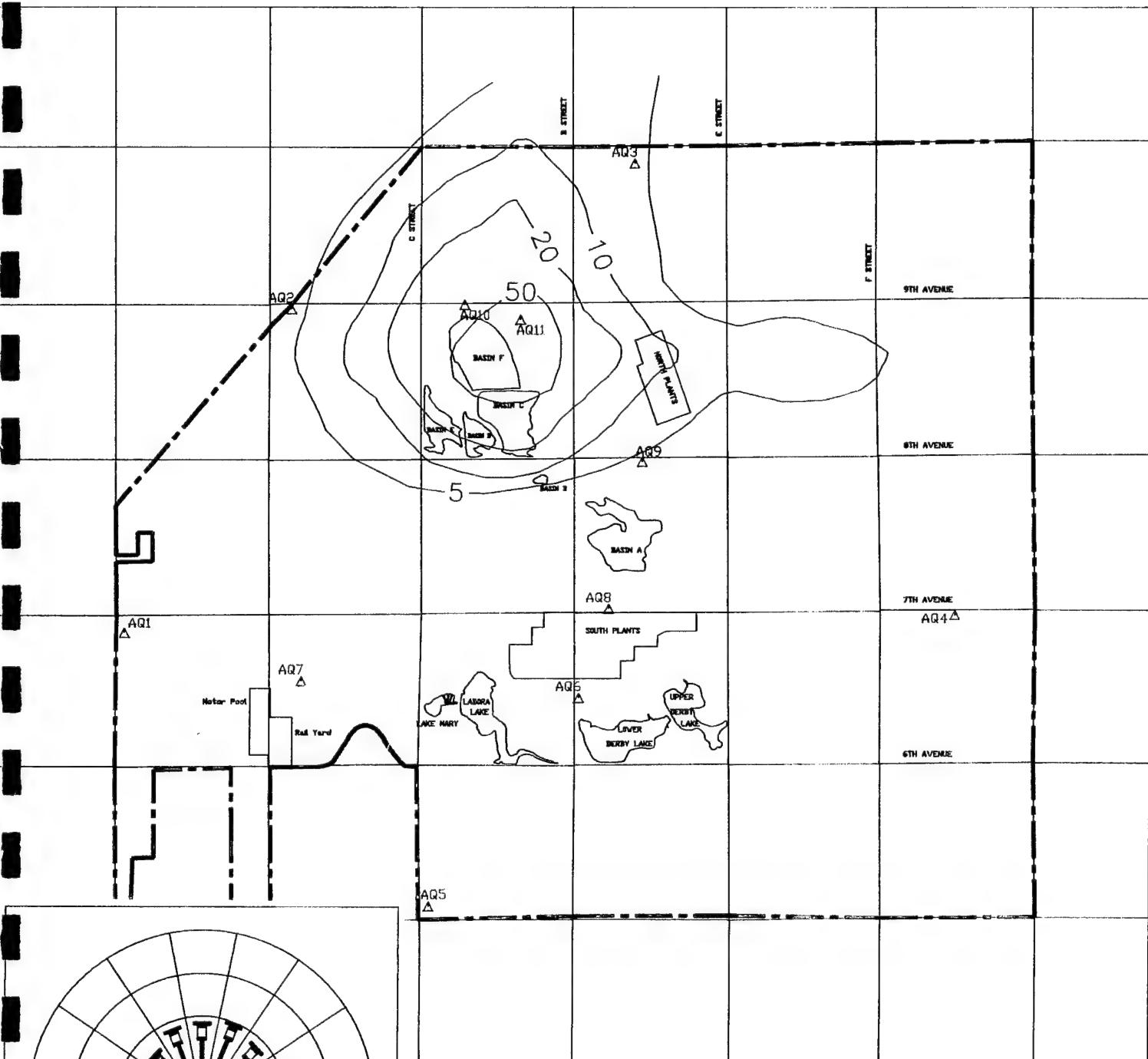
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

x/Q Dispersion for Phase 2 – Stage 2 CMP Air Quality Data

U.S. Program Manager

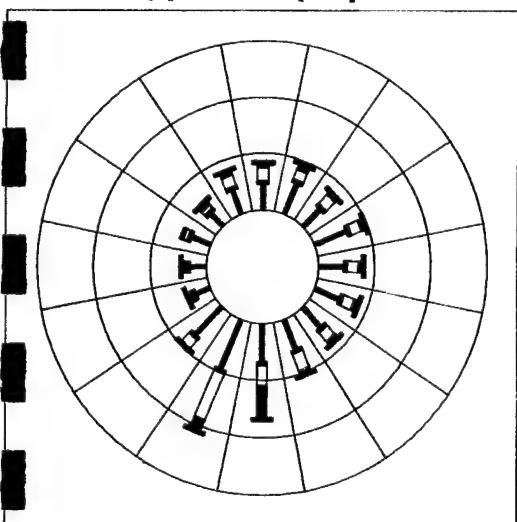
Rocky Mountain Arsenal

DRWN BY : dwb	DATE : 8/4/92	PROJECT NO: 22787E	FIG. NO : 4.1-3
CHKD BY : .	DATE : .		



Source: Basin F

5000 0 5000 10000
SCALE Feet



AQ5 Comprehensive Monitoring Location



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

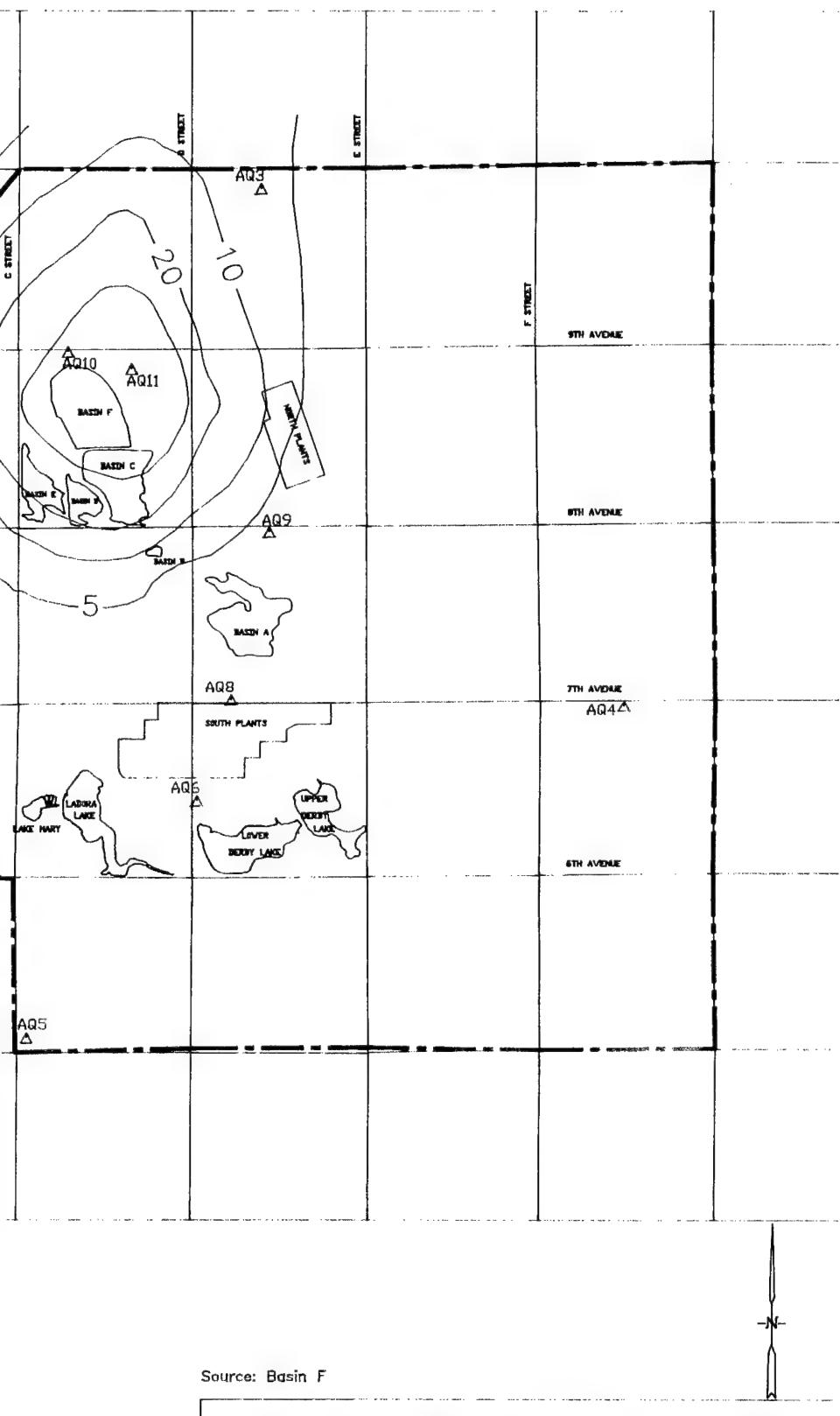
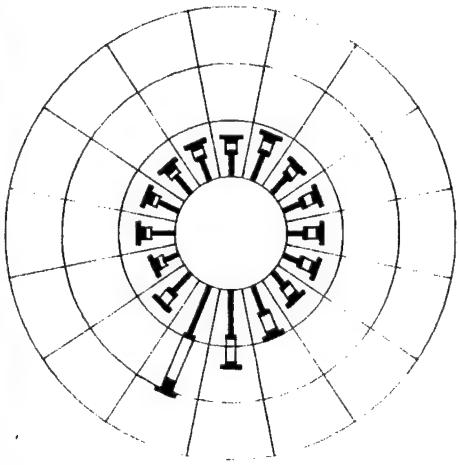
x/Q Dispersion for Phase 3 CMP Air Quality Data

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	dwb	DATE :	8/4/92	PROJECT NO:	
CHKD BY :	.	DATE :	.	22787E	FIG. NO : 4.1-4

AQ5 Comprehensive Monitoring Location



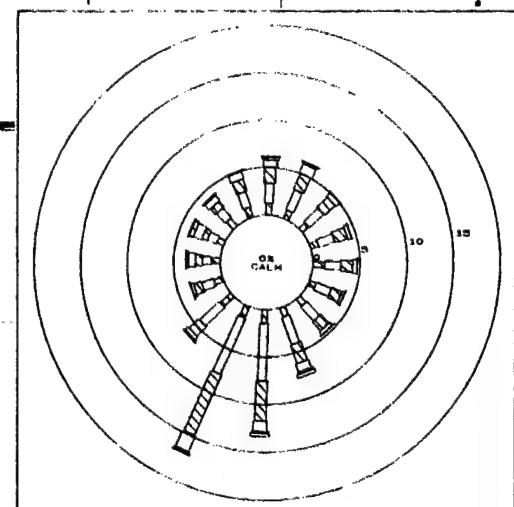
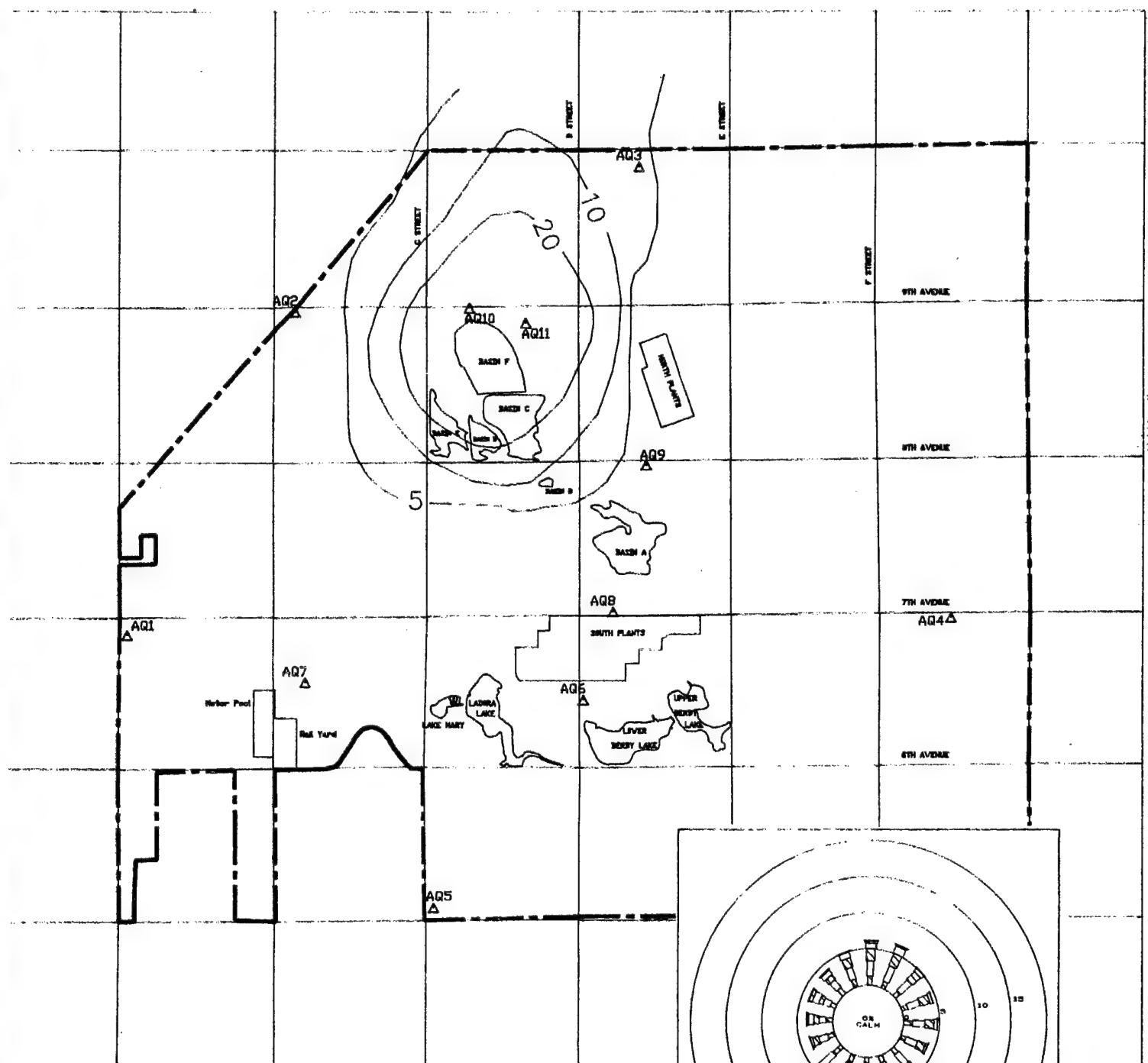
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

x/Q Dispersion for Phase 4 CMP Air Quality Data

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	dwb	DATE :	B/4/92	PROJECT NO:	FIG. NO :
CHKD BY :	.	DATE :	.	22787E	4.1-5



5000 0 5000 10000
SCALE

AQ5 Comprehensive Monitoring Location
SOURCE MODELED AT BASIN F



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

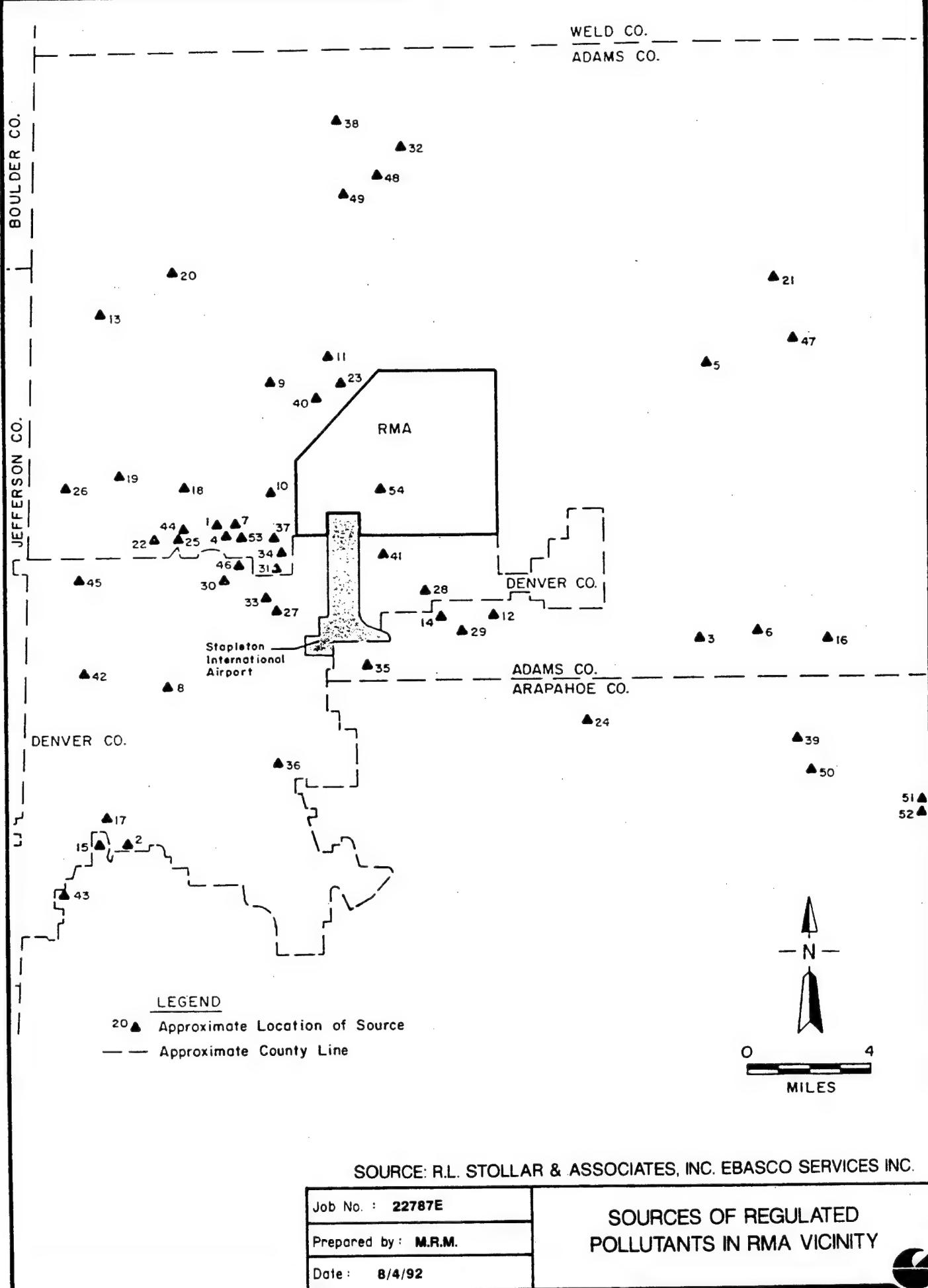
x/Q Dispersion for Phase 5 CMP Air Quality Data

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb	DATE : 9/21/92
CHKD BY :	DATE :

PROJECT NO: 22787E	FIG. NO: 4.1-6
--------------------	----------------



4.2 TOTAL SUSPENDED PARTICULATES (TSP)

4.2.1 CMP FY91 TSP Results

A summary of data sampling frequency and recovery for the FY91 monitoring program for TSP at each of the monitoring locations are presented in Table 4.2-1. Recoveries are based on the total number of planned days during the monitoring year. Samples were considered not valid if there were equipment malfunctions or the sample filter was damaged. According to PSD guidelines, a minimum of 23 hours of sampling was required for a valid sample.

TSP data are often reported by using the annual geometric mean values. This approach is based on early EPA guidance regarding standards, and is applied because the TSP monitoring data can be expected to fit a log-normal distribution. Under a log-normal distribution, there are a relatively large number of low concentrations and a small number of high concentrations. An arithmetic mean value would be greatly affected by the few very large values, while a geometric mean is much less affected by these extremes.

An arithmetic mean can be characterized as:

$$A = (a_1 + a_2 + a_3 + \dots + a_n)/n$$

While a geometric mean is the nth root of the product of the n observations:

$$G = (a_1 a_2 a_3 \dots a_n)^{1/n}$$

Where

- an is the nth observation (of TSP data);
- n is the total number of valid observations;
- A is the arithmetic mean of the sample; and
- G is the geometric mean of the sample.

Monthly and annual TSP results for the FY91 Program for each monitoring station are summarized in Table 4.2-2 and Figure 4.2-1. Figure 4.1-6, previously shown, provides the X/Q-dispersion pattern for the CMP FY91 monitoring period. Table 4.2-2 provides both annual arithmetic and geometric means as well as 24-hour maximum concentrations in standard volumes measured during the monitoring program. The arithmetic mean is provided for continuity purposes and for comparison with previous historical data (i.e., RI data). The 24-hour sequential data are provided in Appendix A.

Annual arithmetic mean values for TSP during FY91 ranged from a high of $61 \mu\text{g}/\text{m}^3$ at AQ2, on the northwest perimeter of RMA, to a low of $34 \mu\text{g}/\text{m}^3$ at AQ9, located between the North Plant and Basin A. Annual geometric mean values ranged from a high of $52 \mu\text{g}/\text{m}^3$ to a low of $30 \mu\text{g}/\text{m}^3$. During FY88 and FY89, AQ10 and AQ11, both downwind of Basin F remedial activities, exceeded the annual standards. During FY91, these stations measured annual geometric means of $34 \mu\text{g}/\text{m}^3$ and $41 \mu\text{g}/\text{m}^3$, ranging from 57 to 68 percent of the secondary standard of $60 \mu\text{g}/\text{m}^3$. Table 2.1-1 shows all ambient air quality standards, including TSP. As noted in Figure 4.2-1, the ambient air quality standards for TSP have been superseded by those for PM_{10} and only the PSD increments remain enforceable.

There was one exceedance of the 24-hour primary ambient air quality standard of $260 \mu\text{g}/\text{m}^3$ for TSP and three exceedances of the secondary 24-hour average ambient air quality standard of $150 \mu\text{g}/\text{m}^3$ during FY91. By contrast, there were 27 exceedances of the 24-hour TSP secondary standard during FY89; all of these exceedances occurred during the Basin F remediation period and almost all were at sites close to Basin F cleanup activities.

During FY91, none of the TSP exceedances of the primary or secondary ambient air quality standards were attributable to remediation activities on Basin F. The single exceedance of the primary standard of $260 \mu\text{g}/\text{m}^3$ occurred on September 9, 1991 at AQ11, located northeast of the Basin F area, with a measured TSP concentration of $286 \mu\text{g}/\text{m}^3$. Since there were no observed remedial or other type of intrusive activities in the vicinity of Basin F during this particular sampling day, the observed concentration at AQ11 may have been due to dry conditions previous to the sampling day in combination with strong winds (average hourly wind speeds range between 14 and

20 miles per hour during the last twelve hours of the day). Prevailing wind directions were from the south-southeast to southeast during the majority of the sampling day, suggesting that the observed particulate loading at AQ11 was not necessarily originating from the area immediately surrounding Basin F. In addition, measured TSP concentrations at the remaining AQ sites range from only 24 to 35 $\mu\text{g}/\text{m}^3$ (Q11 and Q12 measured TSP concentrations of 76 and 40 $\mu\text{g}/\text{m}^3$, respectively), which indicate that the TSP concentration at AQ11 is either attributable to very localized natural effects or that the value is an unexplainable anomaly. The anomaly of the observed TSP concentration at AQ11 in comparison to other CMP site values is readily apparent by examining Figure 4.2-2.

The second highest 24-hour TSP concentration which did not exceed the primary standard, but exceeded the secondary standard of 150 $\mu\text{g}/\text{m}^3$, was measured at AQ11 on March 19, 1991, with a TSP concentration of 247 $\mu\text{g}/\text{m}^3$. Since measured TSP concentrations at all of the other CMP sites were also atypically high, the elevated concentrations appear to be attributable to regional impacts in combination with strong, gusty winds. Average wind speeds for this 24-hour period exceeded 17 miles per hour with peak gusts up to 45 miles per hour. Prevailing wind directions were primarily from the south and south-southeast. Figure 4.2-3 presents the TSP concentration distribution on March 19, 1991, and also shows the dispersion pattern that would have resulted from Basin F being the primary TSP source. The regional nature of the observed TSP concentration distribution is verified by examining Figure 4.2-3 and by noting that measure TSP concentrations at other metropolitan Denver sites averaged well above 100 $\mu\text{g}/\text{m}^3$.

The only other TSP concentration measured at a CMP site that exceeded the secondary standard was 202 $\mu\text{g}/\text{m}^3$ at AQ2, located on the northwest perimeter of the RMA, on September 27, 1992. Regional impacts and dry conditions appeared to be the primary contributors to this measured TSP concentration since TSP concentrations at the other

CMP sites range from 87 to 127 $\mu\text{g}/\text{m}^3$ at AQ5 and AQ7, respectively. Only 0.2 inches of precipitation had been recorded during the month of September up until September 27. Wind directions were variable throughout the day with south and southwest winds during the morning and evening hours and primarily north and northeast winds during the middle portion of the day. Wind speeds were not unusually high, with a daily average somewhat less than the monthly average, and the peak average hourly wind speed was only 12.4 miles per hour. The TSP concentration distribution of the CMP sites on September 27, 1991 is presented in Figure 4.2-4.

4.2.2 Assessment of Basin F TSP Post-Remedial Impacts

4.2.2.1 CMP TSP Monitoring Results

Since source impacts from Basin F have varied during the remedial and post-remedial monitoring periods, results and comparisons with all monitored data were considered with respect to the different phases and stages of the cleanup operations. Table 4.2-3 provides a description of annual geometric mean, arithmetic average and 24-hour maximum TSP monitoring results by month from the start of CMP FY89 to the conclusion of CMP FY91. To establish pre-remedial baseline values, results of the 1986-1987 IR Program are also provided (ESE, 1988) (only average and maximum values are shown for these data as geometric means were not calculated). Phase 1 shows results of CMP FY88 and FY89 data which were concurrent with remediation activity; Phase 2 (Stage 1) shows results of the FY89 program after the initial cap was placed on Basin F, but extensive ground moving activities were in progress; Phase 2 (Stage 2) shows results during the final Basin F remedial and landscaping activity. Phase 3 provides post-remedial TSP monitoring data during the last 5 months of the CMP FY89, Phase 4 provides post-remedial TSP monitoring data during the 12 months of CMP FY90 and Phase 5 provides post-remedial monitoring during CMP FY91.

Basin F remedial activity evidently had an impact on those CMP stations that were located immediately adjacent to or downwind from Basin F, especially AQ10, 11, and 12. The highest monthly average and maximum 24-hour concentrations occurred in the latter months of Phase 1 and in Phase 2, Stage 1, when earth moving activities were most intense. A maximum 24-hour TSP value of 738 $\mu\text{g}/\text{m}^3$ was measured at AQ11 on

January 22, 1989. At all stations, TSP levels decreased to preremedial baseline values during the post-remediation periods (Phases 3, 4, and 5). Figure 4.2-5 provides a graphical depiction of the arithmetic means and 24-hour maximum values for each phase at AQ10, the CMP mobile station immediately downwind and north of Basin F. The transitory impacts of remediation activity are evident based on the concentration differences between the remedial and post-remedial phases. TSP levels reached their peak during the intense remediation of Phase 1, then decreased to pre-remedial levels during the post-remediation period. While maximum 24-hour values may have varied extensively on a day-today basis, the same general trend as the average values is evident.

The RMA TSP interior and boundary monitoring stations at farther distances from Basin F showed minimal impacts from the remediation activity, and other variations that were mostly attributed to seasonal and meteorological conditions. TSP data from AQ1 and AQ2 located at the western and northwestern boundaries of RMA, exhibit trends that indicate the greatest impacts are from metropolitan Denver. The highest TSP concentrations at these stations were measured during the winter period of January and February, 1989, coincident with days when downtown Denver experienced very high TSP values. These were periods of intense inversions and the movement of potential "brown cloud" conditions from downtown Denver in the direction of the Arsenal. A discussion of some of these episodes will be presented in later sections.

The results of the CMP data reflecting TSP Basin F remedial impacts are further substantiated by data collected under the Basin F Interim Remediation Monitoring Program, the follow-on IRA-F monitoring program, and recent data from those sites formerly included in the IRA-F monitoring program discussed in the next section.

4.2.2.2 Basin F TSP Monitoring Results

During FY88, FY89, FY90, and the first part of FY91, the CMP air monitoring network at RMA was supplemented and augmented by two major monitoring programs associated with Basin F cleanup activities. These were the Basin F Interim Remediation Air Monitoring Program and the follow-on IRA-F Air Monitoring Program. These programs ran continuously from May 1988 through January 18, 1991. Data continued to be collected at some of the sites formerly part of the IRA-F program during the

integrated monitoring program from January 24, 1991 to September 30, 1991. The network of stations and parameter monitors is discussed in Sections 3.3 and 3.4.

Annual geometric mean, arithmetic mean and 24-hour maximum TSP concentrations collected under the special Basin F monitoring programs, by month and phase are shown in Table 4.2-4. Data from Phases 1 and 2 comprise the Basin F Interim Remediation Monitoring Program, while Phases 3, 4, and 5 comprise data from the IRA-F post-remedial program. Detailed daily results from the IRA-F Phase 5 and former IRA-F sites collecting data under the current integrated program during the remainder of Phase 5 period are also provided in Appendix L.

The Basin F network was designed specifically to evaluate impacts surrounding the remedial activity during and after cleanup operations. The trend of TSP concentrations is illustrated graphically in Figure 4.2-6 which shows geometric mean values during each phase of the program at seven monitoring stations. In all cases, concentration levels dropped significantly during the Phases 3, 4, and 5 post-remedial periods. A distinction has been made between data collected during the IRA-F portion of Phase 5 (Stage 1) and during the integrated program comprising the remainder of Phase 5 (Stage 2).

Individual station impacts reflect the distance from specific remedial activity. For example, BF1/FC1 located at the north end of the basin showed highest levels during the full remediation phase and dropped off to typical RMA baseline levels at the conclusion of remediation work. (All Basin F monitoring stations fell off to RMA background levels at the conclusion of remediation.) The geometric mean TSP concentration at BF1/FC1 was $105 \mu\text{g}/\text{m}^3$ during Phase 1, dropped to $78 \mu\text{g}/\text{m}^3$ during Phase 2, Stage 1, $62 \mu\text{g}/\text{m}^3$ during Phase 2, Stage 2, $49 \mu\text{g}/\text{m}^3$ during Phase 3, was $39 \mu\text{g}/\text{m}^3$ during the Phase 4, and $36 \mu\text{g}/\text{m}^3$ during the Phase 5 portion of the monitoring program. A maximum 24-hour concentration of $399 \mu\text{g}/\text{m}^3$ was measured at BF1 during the Phase 1 remediation period.

Station BF2/FC2, at the northeast perimeter of the Basin F compound, downwind of prevailing wind flow and in close proximity to extensive ground moving activities, measured the highest TSP concentrations during the remediation program. The geometric mean TSP concentration was $122 \mu\text{g}/\text{m}^3$ during Phase 1, $119 \mu\text{g}/\text{m}^3$ during

Phase 2, Stage 1, 81 $\mu\text{g}/\text{m}^3$ during Phase 2, Stage 2, and then dropped to 39 $\mu\text{g}/\text{m}^3$ during Phase 3, 36 $\mu\text{g}/\text{m}^3$ during the Phase 4 post-remedial period, and 35 $\mu\text{g}/\text{m}^3$ during the Phase 5 post-remedial period. Maximum 24-hour concentrations of 902 $\mu\text{g}/\text{m}^3$ during Phase 1, 687 $\mu\text{g}/\text{m}^3$ during Phase 2, Stage 1, and 514 $\mu\text{g}/\text{m}^3$ during Phase 2, Stage 2, were measured at this site on days when extensive remedial activity was proceeding adjacent to the monitoring station. The collocated Station BF2C/FC2D showed similar results.

Station BF3/FC3, at the southern perimeter of Basin F measured geometric mean TSP concentrations of 68, 53, 55, 44, 32, and 31 $\mu\text{g}/\text{m}^3$, respectively during Phase 1, Phase 2 Stage 1, Phase 2 Stage 2, Phase 3, Phase 4, and Phase 5. A maximum concentration of 286 $\mu\text{g}/\text{m}^3$, was measured during the Phase 1 period. The lower TSP concentrations along the southern perimeter during the remediation periods can be partially attributed to the slightly greater distance from remedial and dirt moving activities. However, the primary influence is the prevailing wind pattern in the vicinity of the RMA area and the resultant pollutant dispersion pattern. The dispersion and meteorological influences are best illustrated in Figure 4.1-1, previously shown, which indicates the atmospheric dispersion pattern, assuming that Basin F is the primary emission source, that corresponds to the Phase 1 monitoring period. The relationship between TSP concentrations and potential contributors to those concentrations will be discussed in the next section for each phase of the remedial program. Assuming the Basin F source is the primary influence, the highest TSP concentrations are skewed to the north of the remedial activity during Phase 1. BF3/FC3 along the southern perimeter measured lower TSP concentrations than the stations along the northern perimeter during this period. This trend was also evident during the Phase 5 FY91 period. Station FC3 measured a geometric mean value of 31 $\mu\text{g}/\text{m}^3$ during this post-remedial period, while other monitoring stations to the north of the Basin measured geometric mean values 1 to 4 $\mu\text{g}/\text{m}^3$ higher. The differences were not as significant as during the remedial phases of the Basin F program, and are less than noted during Phase 4. As an example during Phase 1, FC2 to the north measured TSP levels three times those of FC3 to the south. Thus, the TSP data suggest minor residual TSP impacts from the remediated Basin F area. One possible reason could be reseeding and other occasional construction activities over the area which temporarily loosened the soil. Other potential

contaminants such as metals, VOCs, and OCPs also may have been emitted from Basin F.

Station BF4/FC4, along the northwest perimeter of Basin F, measured TSP levels equivalent to BF1/FC1 with a geometric mean value of $117 \mu\text{g}/\text{m}^3$ in Phase 1, but decreased to 42, 35 and $34 \mu\text{g}/\text{m}^3$ during the Phase 3, 4 and 5 post-remedial periods, respectively. A maximum 24-hour TSP concentration of $324 \mu\text{g}/\text{m}^3$ was measured during the Phase 1 remediation period.

FC5 was installed during Phase 3 to the north of Basin F. Although this station measured the highest geometric mean and average value of the five IRA-F monitoring stations during Phase 4, the distinction of having the highest TSP concentrations among the five former IRA-F sites during Phase 5 (FY91) changed to FC1. FC1 had the highest geometric mean of $36 \mu\text{g}/\text{m}^3$, the highest arithmetic mean of $55 \mu\text{g}/\text{m}^3$ and the highest 24-hour concentration of $410 \mu\text{g}/\text{m}^3$ that occurred on November 13, 1990. On that date, special restoration activities on Basin F (straw was placed on the area) were being conducted. Measured TSP concentrations at the other Basin F sites, FC2 through FC5, were also elevated on this sampling date, ranging from 49 to $115 \mu\text{g}/\text{m}^3$, but not to the extent apparent at FC1. The single day event at FC1 somewhat skewed the annual geometric and arithmetic mean values. The arithmetic mean is particularly affected since it is statistically more susceptible to the effects of individual events than the geometric mean value. Generally, the distribution of TSP concentrations among FC1, FC2, FC3, FC5, and FC5 were very similar with less differences than evident during previous monitoring phases.

In summary, the Basin F TSP monitoring program indicated that during the remediation period the highest concentrations were confined to the immediate vicinity of the remedial activity and directly downwind from this activity according to on-going atmospheric dispersion patterns. At the termination of the remediation activity, TSP levels at all monitoring stations were similar to typical interior RMA baseline values, although slightly higher TSP levels were measured downwind from Basin F.

4.2.2.3 Analysis of Combined CMP/Basin F TSP Monitoring Result

Figures 4.2-7 and 4.2-8, which combine CMP and Basin F data for the Phase 1 and Phase 5 periods, provide a comprehensive depiction of TSP levels across RMA during the intense remediation period and the follow-on post-remediation periods, and reinforce conclusions obtained from analysis of the individual monitoring data. During Phase 1, the principal TSP impact was in close proximity to Basin F remedial activity and downwind from the prevailing wind flow. BF2, at the northeast corner of Basin F and adjacent to much of the remedial activity, recorded the highest geometric mean value of $122 \mu\text{g}/\text{m}^3$ during the Phase 1 remedial period. During periods of intense remediation activity and dirt hauling, 24-hour TSP levels reached as high as $600 \mu\text{g}/\text{m}^3$ to above $900 \mu\text{g}/\text{m}^3$ adjacent to the activity. A maximum level of $902 \mu\text{g}/\text{m}^3$ was recorded at BF2 during Phase 1. However, these high levels were localized; TSP concentrations monitored at sites located one mile or more from Basin F and at the RMA perimeters exhibited little or no impact from the operations. During Phase 1, interior RMA CMP sites showed average geometric mean values from $35 \mu\text{g}/\text{m}^3$ to $40 \mu\text{g}/\text{m}^3$ and 24-hour maximum values from $86 \mu\text{g}/\text{m}^3$ to $97 \mu\text{g}/\text{m}^3$. Several of these stations were apparently influenced by other local and regional factors. The influence of regional sources is especially apparent at CMP Stations AQ1 and AQ2 along the western and northwestern boundaries of RMA, which are the closest sites to metropolitan Denver. Prior to the Basin F remediation effort, these two stations measured the highest TSP concentrations of the 12 RMA monitoring sites (RI Monitoring Program, ESE, 1988). During Basin F remediation activity, TSP levels were significantly higher at the Basin F sites; however, during the post-remedial period AQ1 and AQ2 again measured the highest TSP concentrations across the RMA complex.

During the Phase 5 remedial period, TSP concentration data continued to exhibit a significant decrease in Basin F concentrations that were more comparable to other RMA monitoring sites (and regional background levels). Note that the prevailing winds and dispersion patterns (as shown in Figures 4.1-1 through 4.1-6) were essentially the same as the early phases, and the conclusion must be that Basin F became a minor source of airborne dust. During Phase 5, AQ2 at the northwestern boundary of RMA had the highest mean TSP concentrations and the third highest 24-hour maximum value of the

17 TSP monitoring sites; this result is consistent with the preremedial monitoring results of the RI program (ESE, 1988).

Figure 4.2-9 shows a bar graph distribution of TSP geometric mean values at the CMP monitoring sites. Note that AQ10 and AQ11, immediately downwind from Basin F, and AQ12 adjacent to Borrow Pit dirt moving activities, show high TSP levels during the Phase 1 and Phase 2 remediation periods and then decrease significantly during the Phase 3, Phase 4 and Phase 5 post-remedial periods. Other RMA internal locations show little variation in geometric means throughout the remedial monitoring program. However, AQ1 and AQ2 at the western boundaries closest to metropolitan Denver, maintained moderately high TSP concentrations for all phases of the program.

Another interesting aspect of the 43 months of RMA data is that TSP impacts were reduced at all stations during the FY90 post-remedial monitoring period. This may partially be attributed to the remediation of Basin F; however, it is particularly evident from metropolitan Denver data that the fall-winter period of 1989-90 was less severe with respect to inversion and brown cloud conditions. The stations most influenced by Basin F activity, AQ10, AQ11, and AQ12, had TSP levels that were reduced significantly from Phases 1 and 2 (by a factor of over 2.5 at AQ10), while those stations at greater distances from Basin F showed smaller decreases. TSP concentrations during FY91 were generally higher than FY90, but still less than FY89 as a result of the less severe brown cloud season of 1989-90. Thus, TSP concentrations during FY91 were probably more indicative of an average post-remedial phase.

4.2.2.4 Individual Day Remedial Assessment Comparisons

Individual daily impacts varied substantially, depending upon the specific meteorological conditions and the specific remediation activity. For example, Figure 4.2-10 presents a Phase 1 day (September 24, 1988) when light to moderate winds were blowing across Basin F from the south and southwest for several hours in the direction of the AQ11 monitor at the northwest corner of the Basin F perimeter. Most other wind directions throughout the day were variable, as indicated by the wind rose in the top right inset of the figure. Station AQ11 reported a TSP level of $389 \mu\text{g}/\text{m}^3$ for this 24-hour period; Station AQ12, also downwind from Borrow Pit activity, reported $64 \mu\text{g}/\text{m}^3$. All other

stations had relatively low TSP values. AQ10, close to Basin F, but not directly downwind from the apparent source, measured 55 $\mu\text{g}/\text{m}^3$. AQ3, farther downwind, reported 35 $\mu\text{g}/\text{m}^3$, indicating that values were primarily a function of local remediation activity that fell off quickly with distance from the source. All stations upwind from Basin F measured considerably lower values. During a typical post-remedial day on September 26, 1990 (Phase 4), with prevailing southerly wind conditions similar to the Phase 1 day, all TSP values across RMA were at low levels including the previously impacted Basin F sites (see Figure 4.2-11). The wind rose shown on this figure suggests modest potential impacts from a Basin F source; however, this trend was not substantiated by concentrations measured at AQ11 on this post-remedial day.

4.2.3 RMA TSP Causal Effects

The impacts of metropolitan Denver on Arsenal TSP levels will be discussed further in Section 4.2.4. Several studies were also conducted during CMP FY88 and FY89 relating the impacts of wind gusts and source locations to TSP concentrations measured at the various monitoring locations. This section provides a brief update on the status of these investigations. The causal effects of TSP concentrations at RMA monitoring sites are varied and cannot be reduced to two or three sources or unique meteorological events. The impacts of Basin F remediation activity were described in detail in the previous sections. The impacts from metropolitan Denver are also significant and will be discussed further in Section 4.2.4. Other factors such as wind speed, wind direction, precipitation, inversion conditions, seasonal and climatological effects, as well as variable construction and remediation activity at the Arsenal all influence the short-term and long-term monitoring results.

In the CMP FY88 Data Assessment Report, a direct correlation was established between 24-hour TSP levels and strong winds blowing downwind from a remediation source. During the FY88 remediation period, AQ11 downwind from Basin F showed a correlation of 0.4 between TSP levels and winds blowing from the Basin toward the station (+/-30°), as shown in Figure 4.2-12. Further downwind at other RMA sites, the relationship was no longer evident, indicating that these effects were not only wind speed and wind direction dependent, but also distance dependent. The TSP concentration data suggest that at a distance of one mile, remediation impacts became minimal. During

FY89 when the Basin F remediation work was completed, the correlation between high TSP levels at AQ11 and winds blowing off Basin F (shown in Figure 4.2-13) was no longer observed (the correlation was -0.03). The observed data indicated that Basin F was a major TSP source during the remediation activity, but was largely eliminated during the post-remedial period except for minor residual impacts associated with continuing reseeding and construction activities.

A long-term statistical analysis of the RMA data should also document and consider unique remediation and construction activities associated with the data collection period. For example, during FY88 and FY89 the Borrow Pit, which was used as fill dirt for Basin F remediation, contributed significantly to TSP concentrations measured at AQ12, however, these levels decreased in FY90. During FY91, TSP concentrations at AQ11 and AQ12 increased to levels similar to Phase 3 as a result of regional influences. Activity from the Lower Derby Lake spillway area strongly influenced TSP levels at AQ6 in FY90, as evidenced by the lower TSP concentrations during FY91.

In addition to remediation source influences, seasonal and climatological conditions also influenced the data reported. Although some of these effects can be identified in the 43-month database, local and unique meteorological events have overriding influences. Table 4.2-5 shows seasonal TSP results (arithmetic average and 24-hour maximum concentrations) for each of the RMA monitoring sites. The highest Arsenal TSP concentrations occurred in the summer and fall, the lowest in spring, and moderate levels occurred in winter. At AQ1, AQ2, and AQ5 on the west, northwest, and southern boundaries which are closest to metropolitan Denver influences, the highest concentrations occurred in the summer or winter, while the interior Arsenal monitoring sites experienced markedly higher TSP concentrations during the summer period only (exclude Basin F impacted sites AQ10 and AQ11). Highest seasonal average concentrations occurred during the fall at the perimeter sites, AQ1 and AQ2. Metropolitan Denver influences the Arsenal most in the fall and winter during intense inversion periods.

Seasonal summary data also highlight the unique influences of remediation activity at sites AQ10, AQ11, and AQ12. For example, AQ11 experienced especially high concentrations during Basin F cleanup work on several winter days, including a

maximum reported concentration of 738 $\mu\text{g}/\text{m}^3$. Station AQ12 was directly impacted by Borrow Pit activity during the summer of FY88 (maximum of 590 $\mu\text{g}/\text{m}^3$), resulting in a high overall summer seasonal TSP concentration at this station. During FY90, construction activities at the Lower Derby Lake spillway resulted in very high concentrations during the spring and summer months at AQ6, downwind from the activity. The highest seasonal concentrations at this site occurred during the spring and summer seasons during FY90. The anomalously high value of 286 $\mu\text{g}/\text{m}^3$ at AQ11 on September 9, 1991 contributed to significantly higher summer seasonal concentrations during FY91 as compared to previous post-remedial phases.

Table 4.2-6 is a more detailed breakdown of seasonal trends for 10 consecutive quarters from the spring of FY88 to the fall of FY91. Average concentrations and 24-hour maximum levels varied considerably, depending upon both the source influences and the unique meteorological events. Trends in maximum 24-hour TSP values exhibited the impacts of Basin F remediation on AQ10, AQ11 and AQ12 during the first few quarters, as well as the impacts at AQ6 during the spring and summer quarters of FY90. The variability of unique meteorological events was portrayed during the winter of FY89 and the summer of FY90, when extremely high TSP concentrations occurred across the Denver metropolitan area and the Arsenal on February 9, 1989, and September 14, 1990, influencing both maximum concentrations and seasonal averages. Notable seasonal maximum values during FY91, not attributable to metropolitan Denver influences, were evident at AQ11 during the winter and summer seasons. The maximum 24-hour value for either season was somewhat attributable to meteorological conditions rather than a specific remedial activity.

Rather than identifying strong seasonal trends, these data confirm the overriding influence of individual source impacts and meteorological events. As the database continues to expand, real trends in seasonal impacts may become more apparent. As the effect of individual events are further minimized, higher TSP concentrations are anticipated at the perimeter stations close to metropolitan Denver, especially at AQ1 and AQ2, during the fall and winter periods. Higher summer TSP concentrations may be anticipated at Arsenal interior stations due to more frequent construction activity, creating soil conditions that are more favorable to generating airborne dust.

4.2.4 Denver Metropolitan Area TSP Influences

4.2.4.1 CMP FY91 Period Results

RMA activities were not the only TSP sources that influenced the Arsenal and its adjacent boundary areas as evident from previous assessments. The 1986-1987 Remedial Investigation study clearly established that prior to remediation, TSP values were highest at the perimeter stations and lowest in the interior of the Arsenal, suggesting that the principal long-term major sources in the area were the industrial or transportation activities of metropolitan Denver. The Basin F Remediation Program temporarily altered this situation at several sites in the interior of RMA; however, metropolitan Denver sources were still a major contributor.

Table 4.2-7 shows the major stationary sources with TSP emissions of 25 tons per year (tpy) or more surrounding the Arsenal. Several of the sources are located within 2 miles to the west and southwest of RMA, as shown in Figure 4.2-14, and contribute a large portion of the total TSP emissions for Adams, Arapahoe, and Denver counties (CDH, 1992). Compared to the major TSP sources, the Arsenal accounts for a small fraction of the total TSP emissions. In addition to these external stationary sources, dust from vehicle traffic and off-road sources contributes greatly to the TSP emissions.

Table 4.2-8 is a summary of Denver metropolitan area TSP data measured concurrently with the FY91 program as well as with previous remediation and post-remediation phases. Figure 4.2-15 shows the geographic distribution of TSP geometric mean levels across the metropolitan area, including RMA for FY91. The highest levels were in the downtown area at CAMP (2105 Broadway), where TSP concentrations have exceeded the ambient air quality primary and secondary standards for the past 15 years or more. During 1989, maximum 24-hour TSP concentrations in downtown Denver frequently exceeded the 24-hour standard of $150 \mu\text{g}/\text{m}^3$. A maximum level of $472 \mu\text{g}/\text{m}^3$ was recorded at CAMP on January 4, 1989. During FY91, the annual geometric mean at CAMP was $110 \mu\text{g}/\text{m}^3$, well above the annual standard of $60 \mu\text{g}/\text{m}^3$; the maximum 24-hour TSP concentration was $563 \mu\text{g}/\text{m}^3$, again exceeding the 24-hour primary and secondary standards.

Other Denver area TSP monitoring stations measured concentrations also exceeding the 24-hour and annual ambient air quality standards. On several occasions, under intense inversion conditions, high TSP concentrations from the general metropolitan area were transported to the Arsenal. Figure 4.2-3, previously discussed, depicts a day, March 19, 1991, when all monitoring stations (except AQ3) measured TSP concentrations between 64 and 99 $\mu\text{g}/\text{m}^3$ and AQ11 measured a maximum TSP concentration of 247 $\mu\text{g}/\text{m}^3$. TSP concentrations on this day at metropolitan Denver stations were well above 100 $\mu\text{g}/\text{m}^3$. The wind rose pattern shown in Figure 4.2-3 indicates the flow of pollutants from primarily the south and southeast directions, transporting Denver area emissions to the RMA.

As a general rule, concentrations decreased from the center of Denver and were typically about 50 percent lower in the outlying suburbs, including RMA. During 1986-1987 prior to Basin F remediation activity, the average concentration at RMA for all sites was 40 $\mu\text{g}/\text{m}^3$. The boundary sites, AQ1 and AQ2, averaged 56 $\mu\text{g}/\text{m}^3$ and were comparable to other suburban measurements, whereas the interior RMA sites averaged 38 $\mu\text{g}/\text{m}^3$. This trend was temporarily altered during Basin F remediation activities. However, during the FY 91 post-remedial period, the average TSP concentration for all CMP sites was 44 $\mu\text{g}/\text{m}^3$, with the boundary sites averaging 47 $\mu\text{g}/\text{m}^3$ and the interior sites averaging 43 $\mu\text{g}/\text{m}^3$. These results are similar to the pre-remedial monitoring results at RMA.

One important difference between high TSP values measured in metropolitan Denver and those at RMA is that those experienced in metropolitan Denver were frequently associated with high pollution episodes in which industrial and vehicle traffic emissions were trapped under a blanketing inversion that spread across the area. In these cases, winds were generally light to moderate. Occasionally, these metropolitan Denver impacts extended to the vicinity of RMA; however, during remedial operations at RMA, higher concentrations were invariably associated with strong wind gusts that lifted dirt which had been loosened by handling.

4.2.5 Analysis Implications for Mitigation and Controls

The general results of these investigations indicate that many of the RMA sources were localized and that although very high concentrations were frequently measured adjacent to remedial activities, concentrations decreased significantly with distance from the source. Consequently, those sources located in the RMA interior were less likely to cause impacts off the Arsenal, while those sources closer to the boundaries were more likely to cause temporary impacts at the boundary when strong or gusty winds were directed from the source to the boundary.

Also, certain atmospheric conditions and other factors that vary diurnally can spread pollutants greater distances from the disturbing source. The ongoing CMP and summarized data results, with analyses of probable causative factors, form the basis for deciding appropriate mitigating actions. For example, when the monitoring data show excessive TSP concentrations, chemical stabilizers, covers, reseeding, and landscaping can be used over sensitive areas, as in the case of Basins F and A. Dirt excavation, hauling and unloading can be minimized during periods of high winds and poor dispersion potential, particularly when transport of the resultant airborne dust would be towards nearby boundaries.

4.2.6 Summary

TSP concentrations observed at RMA can be attributed to two principal sources: (1) the influx of industrial or urban traffic emissions from metropolitan Denver, and (2) remedial activity producing wind-blown dust, usually during high wind episodes. A noticeable increase in TSP concentrations at sites adjacent to or directly downwind from construction work, primarily at Basin F, occurred during the FY88 and FY89 CMP monitoring periods because of increased remedial activity at RMA. However, the impacts from sources originating within RMA were localized and decreased rapidly with distance from the source. During FY90 and FY91 after termination of the Basin F cleanup program, TSP concentrations downwind from Basin F decreased significantly.

TABLE 4.2-1
SUMMARY OF RMA TOTAL SUSPENDED PARTICULATES (TSP)
MONITORING FOR FY91

Station	Samples Scheduled	No. Samples	Percent Recovery
AQ1	42	42	100
AQ2	42	42	100
AQ3	42	42	100
AQ4	42	42	100
AQ5B	42	40	95
AQ6	42	42	100
AQ7	42	42	100
AQ8	42	42	100
AQ9	42	42	100
AQ10	42	40	95
AQ11	42	40	95
AQ12	42	42	100
FC1	30	28	93
FC2	30	23	76
FC3	12	12	100
FC4	12	10	83
FC5	30	23	86
QI1	31	28	90
QI2	31	27	87
PROGRAM TOTAL	722	694	96

TABLE 4.2-2

TOTAL SUSPENDED PARTICULATES (TSP) SAMPLING RESULTS FOR CMP FY91 (in $\mu\text{g}/\text{m}^3$)

Month	AQ1	AQ2	AQ3	AQ4	AQ5	AQ5B	AQ6	AQ7	AQ8	AQ9	AQ10	AQ10a	AQ10b	AQ11	AQ12	QI1	QI2
Summary of Geometric Mean Concentrations ^a																	
October	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
November	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
December	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
January	54	60	29	24	60	50	32	41	30	26	30	31	28				
February	58	52	33	35	63	48	36	43	36	32	38	40	38				
March	38	42	23	26	35	31	25	29	28	25	30	36	32				
April	32	38	24	22	30	24	24	26	23	22	26	31	27	28	24		
May	39	47	37	32	41	36	37	34	35	31	34	41	38	37	31		
June	43	52	48	41	46	39	47	37	43	41	42	50	52	58	47		
July	31	60	35	31	29	27	32	26	26	27	28	31	32	32	44		
August	33	48	35	37	31	33	31	31	33	27	32	47	35	39	53		
September	55	87	61	61	51	52	51	56	66	43	55	88	58	58	55		
ANNUAL	40	52	35	33	39	36	34	34	34	30	34	41	37	40	40		
Summary of Arithmetic Mean Concentrations																	
October	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
November	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
December	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
January	54	61	29	24	62	53	32	41	30	26	30	31	28				
February	61	53	34	35	68	51	37	44	37	34	39	42	40				
March	44	49	25	33	41	38	30	36	37	33	37	63	38				
April	36	44	28	26	33	30	27	31	26	25	32	40	32	33	29		

TABLE 4.2-2
(Concluded)

Month	AQ1	AQ2	AQ3	AQ4	AQ5	AQ5B	AQ6	AQ7	AQ8	AQ9	AQ10	AQ10a	AQ10b	AQ11	AQ12	QI1	QI2
May	41	50	42	35	44	38	41	37	39	34	37			49	42	41	35
June	44	57	50	44	49	41	49	38	45	43	44			53	55	62	51
July	38	71	44	40	37	34	40	33	33	31	35			38	38	40	52
August	36	53	38	43	35	34	34	33	42	30	36			55	38	45	66
September	64	109	70	67	57	57	58	66	72	48	61			123	64	62	64
ANNUAL	46	61	41	39	46	41	39	40	41	34	40			55	42	47	48
Summary of 24-Hour Maximum Concentrations ^b																	
October	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
November	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
December	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
January	60	73	30	26	75	68	34	41	34	28	30			32	29		
February	84	67	41	43	100	68	47	55	51	46	49			52	50		
March	85	85	46	79	94	86	61	81	99	96	87			247	88		
April	67	91	51	48	61	55	54	55	49	49	62			80	57	55	60
May	62	75	62	50	59	51	60	54	62	51	53			106	59	59	76
June	62	94	81	69	75	61	73	58	61	67	59			81	87	94	78
July	52	100	68	63	55	48	60	50	50	45	53			55	56	58	78
August	49	81	50	71	50	47	50	46	82	41	55			99	50	70	108
September	113	202	119	116	87	85	93	127	103	95	102			286	95	90	116
ANNUAL	113	202	119	116	100	86	93	127	103	96	102			286	95	94	116

* No data available

^a Annual geometric mean standard is 75 µg/m³.

^b Second-maximum 24-hour standard is 150 µg/m³. Primary maximum 24-hour standard is 260 µg/m³.

Note: FY91 is the period from October 1, 1990 to September 30, 1991.

TABLE 4.2-3

**TOTAL SUSPENDED PARTICULATES (TSP)
SAMPLING RESULTS FOR CMP PHASES 1-5 (in $\mu\text{g}/\text{m}^3$)**

Month	AO1	AO2	AO3	AO4	AO5	AQ5B	AQ6	AQ7	AQ8	AQ9	AQ10	AQ10a	AQ10b	AQ11	AQ12	QI1	QI2	Summary of Geometric Mean Concentrations					
PHASE 1																							
March	70	93	37	55	60	45	58	59	93										70	44			
April	43	60	33	38	35	40	40	35											38	31			
May	34	41	29	29	28	30	30	25											43	26			
June	38	61	38	37	36	35	39	36											95	77			
July	54	74	45	46	46	52	45	48											89	67			
August	58	80	54	50	45	45	43	49											68	93			
September	44	72	37	31	29	30	27	31											81	61			
October	54	83	53	49	41	42	38	48											169	101			
November	56	63	33	32	38	40	32	36											66	42			
December	82	87	51	43	55	55	45	50											84	44			
PHASE 2 - STAGE 1																							
December	60	57	37	30	41	42	36	41											91	32			
January	57	67	34	26	51	45	29	35											143	59			
February	58	143	40	39	52	47	41	41											239	57			
PHASE 2 - STAGE 2																							
February	29	37	13	12	25	23	17	19											76	13			
March	56	73	34	33	50	47	37	40											119	97			

TABLE 4.2-3
(Continued)

Month	AQ1	AQ2	AQ3	AQ4	AQ5	AQ5B	AQ6	AQ7	AQ8	AQ9	AQ10	AQ10a	AQ10b	AQ11	AQ12	QI1	QI2	Summary of Geometric Mean Concentrations							
																		April	May	June	July	August			
PHASE 3																									
April	41	56	26	31	33	30	27	26	25	26	39							48	29						
May	48	71	30			30	31	32	78	25	57							43	28						
PHASE 4																									
October	66	86	42	43	48	43	44	50	42	38	49							46	42						
November	57	75	37	33	39	38	34	37	31	30	38							33	31						
December	33	63	22	22	35	34	25	26	26	26	25							33	31						
January	40	46	28	25	39	37	24	27	27	24	29							24	21						
February	49	55	28	21	36	36	27	33	28	25	32							28	25						
March	17	21	12	10	15	14	11	13	11	13	12							11	10						
April	24	30	24	20	19	22	21	21	19	36	34							19	19						
May	35	40	29	26	28	29	62	30	29	26	30							30	28						
June	43	70	49	43	47	48	113	44	49	43	46							46	47						
July	31	41	42	25	27	27	36	30	30	25	30							29	29						
August	48	70	51	42	43	46	58	47	47	38	45							44	41						

TABLE 4.2-3
(Continued)

Month	AQ1	AQ2	AQ3	AQ4	AQ5	AQ5B	AQ6	AQ7	AQ8	AQ9	AQ10	AQ10a	AQ10b	AQ11	AQ12	QI1	QI2	Summary of Geometric Mean Concentrations							
																		*	*	*	*	*	*	*	
PHASE 5																									
September	50	57	46	39	42	43	49	46	45	37									36	44	46	39			
October	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
November	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
December	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
January	54	60	29	24	60	50	32	41	30	26	30								31	28					
February	58	52	33	35	63	48	36	43	36	32	38								40	38					
March	38	42	23	26	35	31	25	29	28	25	30								36	32					
April	32	38	24	22	30	24	24	26	23	22	26								31	27	28	24			
May	39	47	37	32	41	36	37	34	35	31	34								41	38	37	31			
June	43	52	48	41	46	39	47	37	43	41	42								50	52	58	47			
July	31	60	35	31	29	27	32	26	26	27	28								31	32	32	44			
August	33	48	35	37	31	33	31	31	33	27	32								47	35	39	53			
September	55	87	61	61	51	52	51	56	66	43	55								88	58	58	55			
Phase 1	50	68	40	40	39	39	35	40	40	38	81								74	55					
Phase 2-1	58	76	37	40	48	45	33	38	39	31	68								145	49					
Phase 2-2	44	58	26	27	37	34	29	30	29	28	44								72	41					
Phase 3	42	52	37	37	36	36	38	38	38	32	41								37	36					
Phase 4	40	52	32	27	33	33	36	32	31	28	30	36	44	30	28	34	30	34	41	47	40	40			
Phase 5	40	52	35	33	39	36	34	34	34	30	34								41	47	40	40			

TABLE 4.2-3
(Continued)

Month	AQ1	AQ2	AQ3	AQ4	AQ5	AQ5B	AQ6	AQ7	AQ8	AQ9	AQ10	AQ10a	AQ10b	AQ11	AQ12	QI1	QI2	Summary of Arithmetic Mean Concentrations																	
																		PHASE 1	PHASE 2 - STAGE 1	PHASE 2 - STAGE 2	PHASE 3 - STAGE 1	PHASE 3 - STAGE 2	PHASE 4 - STAGE 1	PHASE 4 - STAGE 2	PHASE 5 - STAGE 1	PHASE 5 - STAGE 2	PHASE 6 - STAGE 1	PHASE 6 - STAGE 2	PHASE 7 - STAGE 1	PHASE 7 - STAGE 2	PHASE 8 - STAGE 1	PHASE 8 - STAGE 2	PHASE 9 - STAGE 1	PHASE 9 - STAGE 2	PHASE 10 - STAGE 1
March	71	94	55	59	62	50	61	63	63	63	61	63	63	63	63	63	63	83	47	47	47	47	47	47	47	47	47	47	47	47					
April	50	65	41	45	43	43	46	46	43	43	46	46	43	43	43	43	43	49	37	37	37	37	37	37	37	37	37	37	37	37					
May	36	43	31	31	29	27	32	31	27	31	27	31	27	31	27	31	27	55	28	28	28	28	28	28	28	28	28	28	28	28					
June	42	65	42	40	38	37	41	42	39	41	42	39	41	42	39	41	42	101	102	102	102	102	102	102	102	102	102	102	102	102					
July	57	76	48	48	48	48	47	47	47	47	47	47	47	47	47	47	47	95	70	70	70	70	70	70	70	70	70	70	70	70					
August	66	97	60	58	50	50	47	55	55	55	55	55	52	52	52	52	52	76	163	163	163	163	163	163	163	163	163	163	163	163	163				
September	56	88	51	42	39	39	36	41	42	36	41	42	36	36	36	36	36	157	93	93	93	93	93	93	93	93	93	93	93	93	93				
October	56	87	56	50	43	44	39	49	49	44	44	48	48	48	48	48	48	228	108	108	108	108	108	108	108	108	108	108	108	108	108				
November	57	66	34	33	39	41	32	38	34	33	33	33	33	33	33	33	33	44	44	44	44	44	44	44	44	44	44	44	44	44					
December	92	104	61	51	59	59	50	54	56	59	59	59	59	59	59	59	59	118	49	49	49	49	49	49	49	49	49	49	49	49	49				
PHASE 2 - STAGE 1		PHASE 2 - STAGE 2		PHASE 3 - STAGE 1		PHASE 3 - STAGE 2		PHASE 4 - STAGE 1		PHASE 4 - STAGE 2		PHASE 5 - STAGE 1		PHASE 5 - STAGE 2		PHASE 6 - STAGE 1		PHASE 6 - STAGE 2		PHASE 7 - STAGE 1		PHASE 7 - STAGE 2		PHASE 8 - STAGE 1		PHASE 8 - STAGE 2		PHASE 9 - STAGE 1		PHASE 9 - STAGE 2		PHASE 10 - STAGE 1		PHASE 10 - STAGE 2	
December	64	57	40	32	47	48	40	46	46	39	39	34	34	34	34	34	107	35	35	35	35	35	35	35	35	35	35	35	35	35					
January	68	76	37	30	58	54	36	41	42	32	32	92	92	92	92	92	231	118	118	118	118	118	118	118	118	118	118	118	118	118					
February	90	150	57	53	65	79	67	70	64	63	63	73	73	73	73	73	292	66	66	66	66	66	66	66	66	66	66	66	66	66					

TABLE 4.2-3
(Continued)

Month	AQ1	AQ2	AQ3	AQ4	Summary of Arithmetic Mean Concentrations								
					AQ5	AQ5B	AQ6	AQ7	AQ8	AQ9	AQ10	AQ10a	AQ10b
PHASE 3													
May	44	41	34	34	38	34	37	35	34	36	38	35	
June	40	50	35	39	36	34	36	36	33	41	35	34	
July	59	92	52	51	49	50	51	53	65	47	65	57	57
August	35	51	33	32	32	32	33	33	29	42	42	36	35
September	32	70	52	52	43	51	54	46	37	45	39	39	
PHASE 4													
October	76	97	55	49	56	53	50	56	48	45	56	53	47
November	59	79	39	35	40	39	36	38	33	32	40	35	33
December	35	70	24	23	37	36	26	27	27	26	27	25	22
January	43	48	29	27	48	47	26	28	30	25	30	25	22
February	53	60	31	23	42	41	30	37	32	30	36	32	29
March	21	30	14	12	19	18	14	16	13	14	15	13	12
April	30	38	30	24	27	26	26	25	25	23	36	34	23
May	38	43	31	28	31	31	88	31	32	28	33	35	30
June	46	82	53	47	49	51	175	47	52	47	53	48	51
July	35	47	46	28	30	30	44	33	34	28	34	32	33
August	52	72	54	43	47	47	65	48	49	39	46	46	42
September	67	75	65	56	58	60	71	62	64	54	36	64	68

TABLE 4.2-3
(Continued)

Month	AQ1	AQ2	AQ3	AQ4	AQ5	AQ5B	AQ6	AQ7	AQ8	AQ9	AQ10	AQ10a	AQ10b	AQ11	AQ12	QI1	QI2	Summary of Arithmetic Mean Concentrations									
PHASE 5																											
October	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
November	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
December	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
January	54	61	29	24	62	53	32	41	30	26	30	31	28														
February	61	53	34	35	68	51	37	44	37	34	39	42	40														
March	44	49	25	33	41	38	30	36	37	33	37	63	38														
April	36	44	28	26	33	30	27	31	26	25	32	40	32	29													
May	41	50	42	35	44	38	41	37	39	34	37	49	42	41	35												
June	44	57	50	44	49	41	49	38	45	43	44	53	55	62	51												
July	38	71	44	40	37	34	40	33	33	31	35	38	38	40	52												
August	36	53	38	43	35	34	34	33	42	30	36	55	38	45	66												
September	64	109	70	67	57	57	58	66	72	48	61	125	64	62	64												
Pre-Rem	55	52	35	42	42	38	39	38	36	44	38																
Phase 1	56	77	47	47	43	39	45	44	43	99	103	79															
Phase 2-1	73	88	44	37	62	59	45	50	47	41	84	214	81														
Phase 2-2	49	64	30	31	42	39	32	34	31	51	96	77															
Phase 3	46	61	41	42	40	40	42	43	36	46	41	40															
Phase 4	47	63	39	33	40	40	55	38	37	34	35	41	64	37	34												
Phase 5	46	61	41	39	46	41	39	40	41	34	40	55	42	47	48												

TABLE 4.2-3
(Continued)

Month	Summary of 24-Hour Maximum Concentrations															
	AQ1	AQ2	AQ3	AQ4	AQ5	AQ5B	AQ6	AQ7	AQ8	AQ9	AQ10	AQ10a	AQ10b	AQ11	AQ12	QI1
PHASE 1																
March	79	111	95		83	78	70	80	86	93			126	64		
April	88	118	87		87	83	86	86	87	86			101	81		
May	53	63	43		47	45	36	50	43	38			118	45		
June	67	96	73		64	62	61	63	75	67			166	238		
July	82	100	74		64	65	56	65	59	62			152	111		
August	105	196	96		120	82	81	78	91	87	89		115	590		
September	94	138	94		84	71	69	63	75	72	46		389	190		
October	81	129	76		72	69	73	54	66	61	57		542	165		
November	69	82	46		37	51	53	42	54	48	46		72	71		
December	134	162	93		79	82	83	71	73	76	85		201	72		
PHASE 2 - STAGE 1																
December	87	60	64		45	76	78	62	65	62	52		141	189	52	
January	131	149	68		63	117	113	79	88	79	65		175	738	425	
February	179	198	113		102	183	172	143	156	130	127		146	561	116	
PHASE 2 - STAGE 2																
February	47	47	21		17	43	40	26	32	26	25		29	148	20	
March	86	115	53		58	75	68	57	59	55	65		122	294	467	
April	64	84	51		43	53	48	54	49	50	41		71	93	49	
May	48	71	30					30	31	32	28		57	43	28	

TABLE 4.2-3
(Continued)

Month	AQ1	AQ2	AQ3	AQ4	AQ5	AQ5B	AQ6	AQ7	AQ8	AQ9	AQ10	AQ10a	AQ10b	AQ11	AQ12	Q11	Q12	Summary of 24-Hour Maximum Concentrations											
																		PHASE 3	PHASE 4	PHASE 5	PHASE 6	PHASE 7	PHASE 8	PHASE 9	PHASE 10	PHASE 11	PHASE 12		
May	52	51	41	45	44	46	42	45	43	40	45	46	40	45	45	45	45	56	43										
June	75	117	82	82	79	78	76	79	84	76	73	76	76	73	76	76	76	80											
July	82	124	80	74	72	73	76	78	78	68	90	84	84	86	84	84	84	86											
August	48	68	42	52	44	44	43	41	47	38	49	43	43	48	43	43	43	48											
September	82	130	82	92	63	64	64	63	70	59	75	75	75	75	75	75	75	66	65										
October	133	161	98	73	96	93	84	91	84	76	100	97	97	82															
November	80	107	57	54	56	53	52	54	50	49	58	53	53	46															
December	45	116	45	34	53	51	34	36	34	29	46	29	29	26															
January	72	73	47	39	124	122	45	46	50	37	42	39	39	31															
February	85	102	67	46	86	85	64	76	68	67	70	70	70	63															
March	46	76	28	22	38	36	25	31	24	20	32	28	28	21															
April	52	65	48	31	43	42	38	43	40	37	41	34	34	37															
May	59	66	51	49	53	56	247	53	64	51	59	57	57	51															
June	67	127	83	67	63	67	396	62	77	85	92	75	75																
July	55	73	77	42	43	44	74	51	49	47	57	48	48	54															
August	86	104	77	61	67	66	133	72	78	58	68	67	67	60															
September	184	208	194	171	170	181	212	180	188	164	36	169	169	214	167														

TABLE 4.2-3
(Continued)

Month	AQ1	AQ2	AQ3	AQ4	AQ5	AQ5B	AQ6	AQ7	AQ8	AQ9	AQ10	AQ10a	AQ10b	AQ11	AQ12	QI1	QI2	Summary of 24-Hour Maximum Concentrations									
PHASE 5																											
October		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
November		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
December		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
January	60	73	30	26	75	68	34	41	34	28	30	32	29														
February	84	67	41	43	100	68	47	55	51	26	49	52	50														
March	85	85	46	79	94	86	61	81	99	96	87	247	88														
April	67	91	51	48	61	55	54	55	49	49	62	80	57	55	60												
May	62	75	62	50	59	51	60	54	62	51	53	106	59	59	76												
June	62	94	81	69	75	61	73	58	61	67	59	81	87	94	78												
July	52	100	68	63	55	48	60	50	50	45	55	55	56	58	78												
August	49	81	50	71	50	47	50	46	82	41	102	99	50	70	108												
September	113	202	119	116	87	85	93	127	103	95	55	286	95	90	116												
Pre-Rem	143	112	80	47	109	151	101	95	82	71	91	77															
Phase 1	134	196	96	120	87	83	86	91	87	93	279	542	590														
Phase 2-1	179	198	113	102	183	172	143	156	130	127	175	738	425														
Phase 2-2	86	115	53	58	75	68	57	59	78	65	122	294	467														
Phase 3	82	130	82	92	79	78	76	78	84	76	90	84	86														
Phase 4	184	208	194	171	170	181	396	180	188	164	100	92	169	214	167												
Phase 5	113	202	119	116	100	86	93	127	103	96	102	286	95	94	116												

* Samples not collected at this site for this time period.

**TABLE 4.2-3
(Concluded)**

Note: Pre-Rem refers to data collected during the Air Remedial Investigation, June 1986 to June 1987 (Environmental Science & Engineering, Inc., 1988), where only arithmetic mean and maximum data were available.

Phase 1 is from March 22 to December 12, 1988.

Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.

Phase 2, Stage 2 is from February 15 to May 5, 1989.

Phase 3 is from May 6 to September 30, 1989.

Phase 4 is from October 1, 1989 to September 30, 1990 (FY90).

Phase 5 is from October 1, 1990 to September 30, 1991 (FY91).

AQ10 was located north of Basin F from October 1, 1989 through April 19, 1990.
AQ10a was located in the northeast corner of Section 35 from April 20 to September 4, 1990.
AQ10b was located in the northwest quarter of Section 1 from September 5, 1990 through the end of FY90.

TABLE 4.2-4

**TOTAL SUSPENDED PARTICULATES (TSP) SAMPLING RESULTS
FOR BASIN F/IRA-F/RIFS PHASES 1-5 (in $\mu\text{g}/\text{m}^3$)**

Summary of Geometric Mean Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
PHASE 1												
May	121	45	63		84	88		80	43			
June	75	81	112		130	59		100	47			
July	113	144	177	114	143	74		102	60			
August	82	88	75	60	83	67		56	49			
September	173	171	263	51	119	51		201	38			
October	163	185	192	99	166	75		126	63			
November	251	132	75	49	92	34		43	29			
December	149	210	180	61	138	73		58	44			
PHASE 2 - STAGE 1												
December	88	213	625	63	73	55		74	40	81	74	51
January	66	90	142	40	62	42		69	36	60	65	42
February	100	114	75	97	112	86		102	76	85	108	52

* Annual geometric mean standard is $75 \mu\text{g}/\text{m}^3$.

** No data available.

d Samples at this site discontinued

TABLE 4.2.4
(Continued)

Summary of Geometric Mean Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
PHASE 2 - STAGE 2												
February	58	82	134	53	63	50	235	44	35	48	25	
March	65	111	120	62	78	38	128	35	58	45	64	
April	64	65	98	53	95	58	87	60	67	86	d	
May	46	36	46	38	104	47	44	44	59	d		
PHASE 3												
May	45	43	44	42	46	41	d	40	51			
June	**	25	27	34	27	26	46	27	27			
July	**	54	59	59	62	d	64	d	d			
August	45	42	422	48	42				59			
September	59	45	46	44	46	49						
PHASE 4												
October	79	77	78	70	68				82			
November	47	37	38	40	36				45			
December	27	24	26	26	27				37			

* Annual geometric mean standard is 75 µg/m³.

** No data available.

d Samples at this site discontinued

TABLE 4.2.4
(Continued)

Summary of Geometric Mean Concentrations*

Month	BF1/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
January	34	27	27	19	24							28
February	34	27	27	19	24							28
March	9	9	10	8		10						10
April	33	31	33	31	32		39					
May	22	26	27	18	27		29					
June	49	51	53	36	47		59					
July	45	40	38	37	40		53					
August	64	70	74	51	62		76					
September	75	65	64	62	57		92					
PHASE 5 - STAGE 1												
October	18	18	d	18		18	17					16
November	94	41		46		57						65
December	30	30		26		30						31
January	36	34		30		35						46

* Annual geometric mean standard is 75 $\mu\text{g}/\text{m}^3$. ** No data available.

d Samples at this site discontinued

22787E/RPT4.2-4 09-21-92(4:16pm)/RPT/S

TABLE 4.2-4
(Continued)

Summary of Geometric Mean Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
PHASE 5 - STAGE 2												
January	30	**			29	32				31		
February	33	**			32	34				40		
March	31	35			27	29				37		
April	36	36			20	20				41		
May	27	30			19	40				30		
June	45	50			55	**				55		
July	15	16			29	39				7		
August	32	33			47	**				33		
September	27	55			60	49				67		
Phase 1	105	122	135	68	117	64				89	47	
Phase 2-1	78	119	190	53	72	48				76	44	
Phase 2-2	62	81	104	55	80	45				109	43	
Phase 3	49	39	40	44	42	31	54	d	32	35	d	d
Phase 4	39	36	37	32	35	d	44	d	d			

* Annual geometric mean standard is 75 $\mu\text{g}/\text{m}^3$. ** No data available.

d Samples at this site discontinued

TABLE 4.2.4
(Continued)

Summary of Geometric Mean Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
Phase 5-1	44	32	d	31	36				40			
Phase 5-2	32	36		31	33				31			

* Annual geometric mean standard is 75 $\mu\text{g}/\text{m}^3$. ** No data available.

d Samples at this site discontinued

TABLE 4.2-4
(Continued)

Summary of Arithmetic Mean Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
PHASE 1												
May	122	48	63		95	95			102	50		
June	84	96	140		143	63			105	49		
July	119	190	190	116	144	75			105	61		
August	87	106	103	69	96	93			61	55		
September	221	252	331	79	158	59			249	43		
October	175	204	202	114	174	76			142	64		
November	121	235	121	52	112	37			49	31		
December	106	238	204	65	169	91			60	47		
PHASE 2 - STAGE 1												
December	95	327	626	69	74	61			130	54	82	75
January	94	112	162	42	69	50			80	38	67	65
February	105	118	75	102	116	87			102	77	102	112
												67

* Annual geometric mean standard is 75 $\mu\text{g}/\text{m}^3$.

** No data available.

d Samples at this site discontinued

TABLE 4.2.4
(Continued)

Summary of Arithmetic Mean Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
PHASE 2 - STAGE 2												
February	65	88		134		56	70	50		235	44	48
March	69	162		166		67	83	39		187	36	62
April	70	72		99		59	108	58		87	61	70
May	47	37		46		39	104	47		44	44	59
PHASE 3												
May	45	43		44		42		46		41		51
June	**	28		30		36		31		46		30
July	**	61		67		65		70		d		32
August	46	42		43		48		43		60		d
September	69	48		50		49		50		54		
PHASE 4												
October	83	82		84			73		70		89	
November	48	38		39			41		37		48	
December	27	24		26			26		27		26	

* Annual geometric mean standard is 75 $\mu\text{g}/\text{m}^3$.

** No data available.

d Samples at this site discontinued

TABLE 4.2.4
(Continued)

Summary of Arithmetic Mean Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
January	35	29	27	28	27	27	27	27	27	37	37	
February	35	27	27	20	24	24	24	24	28	28	28	
March	10	11	11	9	11	11	11	11	11	11	11	
April	34	32	33	31	33	33	33	33	39	39	39	
May	22	28	30	18	29	29	29	29	31	31	31	
June	53	51	53	37	49	49	49	49	60	60	60	
July	46	41	40	38	41	41	41	41	56	56	56	
August	65	70	74	54	66	66	66	66	77	77	77	
September	105	97	97	83	82	82	82	82	184	184	184	

PHASE 5 - STAGE 1

October	18	18	d	18	18	17	17	16	16			
November	168	43		50	50	65	65	75	75			
December	32	31		29	29	32	32	33	33			
January	36	34		30	30	35	35	46	46			

* Annual geometric mean standard is 75 $\mu\text{g}/\text{m}^3$. ** No data available.

d Samples at this site discontinued

Sheet 8 of 15

22787/RT4.2-4 09-21-92(4:16pm)/RPT/5

TABLE 4.2.4
(Continued)

Summary of Arithmetic Mean Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
PHASE 5 - STAGE 2												
January	30	**			29	32				31		
February	35	**			35	37				46		
March	33	37			28	30				39		
April	39	41			20	20				46		
May	29	33			19	40				33		
June	49	54			55	**				60		
July	21	20			29	39				7		
August	36	39			47	**				37		
September	37	55			60	49				67		
Phase 1	123	173	178	83	137	74				112	51	
Phase 2-1	96	173	267	60	79	56	96	50	76	77	52	
Phase 2-2	66	110	134	60	88	47	147	45	62	64	48	
Phase 3	53	43	45	47	46	35	57	d	34	39	d	d
Phase 4	49	46	47	40	43	d	62	d	d	d	d	

* Annual geometric mean standard is 75 $\mu\text{g}/\text{m}^3$. ** No data available.
22787/RT4.2-4 09-21-92(4:16pm)/RPT/5

d Samples at this site discontinued

TABLE 4.2-4
(Continued)

Summary of Arithmetic Mean Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
Phase 5-1	91	34		36	43	d	48					
Phase 5-2	37	41		34	35		45					

* Annual geometric mean standard is 75 $\mu\text{g}/\text{m}^3$.

** No data available.

d Samples at this site discontinued

TABLE 4.2-4
(Continued)

Summary of 24-Hour Maximum Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
PHASE 1												
May	128	66	63		158	128		202	88			
June	163	240	318		295	104		129	76			
July	164	370	296	151	167	82		141	71			
August	165	277	235	175	175	260		100	94			
September	399	591	622	274	324	120		430	75			
October	315	309	305	286	233	95		283	81			
November	251	902	282	96	204	46		82	46			
December	149	367	354	98	280	167		70	70			
PHASE 2 - STAGE 1												
December	161	687	659	111	94	85		236	89	98	95	81
January	276	285	255	59	132	120		171	52	183	77	72
February	154	147	75	143	162	95		105	86	162	143	121

*Second-maximum 24-hour standard is 150 $\mu\text{g}/\text{m}^3$.

^aNo data available

^bSamples at this site discontinued

TABLE 4.2-4
(Continued)

Summary of 24-Hour Maximum Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
PHASE 2 - STAGE 2												
February	107	115	134	83	116	50	235	44	73	48	43	
March	104	514	471	106	130	55	493	52	99	59	77	
April	104	103	107	107	160	71	91	76	111	109	d	
May	47	41	46	46	104	47	44	44	59	d		
PHASE 3												
May	47	50	50	48	51	46	d	45	52			
June	**	38	39	50	40	44	46		39	42		
July	**	89	96	94	103	d	87	d	d			
August	48	44	45	51	47		68					
September	105	67	70	69	40		76					
PHASE 4												
October	114	117	122	89	92		135					
November	57	48	50	49	50		71					
December	27	25	26	27	28		26					

*Second-maximum 24-hour standard is 150 $\mu\text{g}/\text{m}^3$.

^aSamples at this site discontinued

TABLE 4.2-4
(Continued)

Summary of 24-Hour Maximum Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
January	42	37		37		37		31		43		
February	41	28		27		26		27		31		
March	14	15		15		12		16		15		
April	40	38		39		38		39		39		
May	25	46		50		21		46		39		
June	72	58		59		53		62		67		
July	56	49		48		46		51		80		
August	78	72		75		70		87		85		
September	227	220		220		173		181		471		
PHASE 5 - STAGE 1												
October	18	18		d		18		17		16		
November	410	54				67		104		115		
December	46	44				43		46		48		
January	36	34				31		35		46		

*Second-maximum 24-hour standard is 150 $\mu\text{g}/\text{m}^3$.
 22787E/R774.2-4 11-03-92(8:32pm)/RPT/5

^aNo data available

^dSamples at this site discontinued

TABLE 4.2.4
(Continued)

Summary of 24-Hour Maximum Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFS1D	RIFS2
PHASE 5 - STAGE 2												
January	30	**		29		32				31		
February	47	**		49		51				68		
March	49	52		39		42				51		
April	58	61		22		20				62		
May	40	46		19		40				46		
June	87	98		55		**				87		
July	35	33		29		39				7		
August	59	60		47		**				55		
September	63	55		60		49				68		
Phase 1	399	902	622	286	324	260				430	94	
Phase 2-1	276	687	659	143	162	120				236	89	183
Phase 2-2	107	514	471	107	160	71				493	76	111
Phase 3	105	89	96	94	103	46	87	d	45	52	d	d
Phase 4	227	220	220	173	181	d	471	d	d	d	d	d

*Second-maximum 24-hour standard is 150 $\mu\text{g}/\text{m}^3$.

^aNo data available

^dSamples at this site discontinued

TABLE 4.2-4
(Concluded)

Summary of 24-Hour Maximum Concentrations*

Month	BFI/FC1	BF2/FC2	BF2C/FC2D	BF3/FC3	BF4/FC4	BF5	FC5	BF6	BF7	RIFS1	RIFSID	RIFS2
Phase 5-1	410	54		67	104		115					
Phase 5-2	87	98		60	51		87					

*Second-maximum 24-hour standard is 150 $\mu\text{g}/\text{m}^3$.

**No data available ^dSamples at this site discontinued

- Note:
- Phase 1 is from March 22 to December 12, 1988.
 - Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.
 - Phase 2, Stage 2 is from February 16 to May 5, 1989.
 - Phase 3 is from May 5 to September 30, 1989.
 - Phase 4 is from October 1, 1989 to September 30, 1990.
 - Phase 5, Stage 1 is from October 1, 1990 to January 22, 1991.
 - Phase 5, Stage 2 is from January 23, 1991 to September 30, 1991.

The Basin F sites were redesignated as "FC" sites upon commencement of the IRA-F program. Sites BF3 and BF4 remained in operation until June 1989, when they were moved slightly within the same area and designated as "FC" sites under the IRA-F program.

TABLE 4.2-5
COMBINED SEASONAL TSP CONCENTRATIONS
FOR FY 88 TO FY 91 (in $\mu\text{g}/\text{m}^3$)

	Fall	Winter	Spring	Summer
ARITHMETIC AVERAGE				
AQ1	62	57	40	52
AQ2	84	64	49	75
AQ3	44	33	33	52
AQ4	41	30	29	48
AQ5	44	56	36	44
AQ5B	44	49	34	44
AQ6	39	35	43	53
AQ7	45	40	34	45
AQ8	40	36	35	48
AQ9	40	32	32	41
AQ10	71	47	35	64
AQ11	89	86	49	66
AQ12	53	53	37	52
QI1	*	*	37	52
QI2	*	*	32	57
SEASONAL AVERAGE	54	48	37	54
24-HOUR MAXIMUM				
AQ1	134	179	88	184
AQ2	162	198	118	208
AQ3	98	113	95	194
AQ4	79	102	79	171
AQ5	96	183	94	170
AQ5B	93	172	86	181
AQ6	84	143	396	321
AQ7	91	156	86	180
AQ8	84	130	99	188
AQ9	85	127	96	164

TABLE 4.2-5
(Concluded)

24-HOUR MAXIMUM				
AQ10	279	175	122	252
AQ11	542	738	247	388
AQ12	165	467	238	590
QI1	*	*	59	94
QI2	*	*	60	116
SEASONAL MAXIMUM	279	738	396	590

* No data available.

TABLE 4.2.6
SEASONAL TSP CONCENTRATIONS BY SITE
(in $\mu\text{g}/\text{m}^3$)

	24-HOUR MAXIMUM												FY91	
	FY89						FY90							
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer
AQ1	88	105	134	179	64	82	133	85	61	184	*	84	85	113
AQ2	118	196	162	198	85	130	161	102	91	208	*	73	91	202
AQ3	95	96	93	113	51	82	98	67	61	194	*	41	62	119
AQ4	120	79	102	45	92	73	46	52	171	*	43	79	116	
AQ5	87	82	82	183	53	79	96	124	53	170	*	100	94	87
AQ5B	83	81	83	172	48	78	93	122	56	181	*	68	86	85
AQ6	86	78	71	143	54	76	84	64	396	321	*	47	61	93
AQ7	86	91	73	156	49	78	91	76	60	180	*	55	81	127
AQ8	87	87	76	130	78	84	84	68	64	188	*	51	99	103
AQ9	93	89	85	127	41	76	76	67	51	164	*	46	96	95
AQ10	252	279	175	122	90	100	70	41	*	*	.49	87	102	
AQ11	166	388	542	738	214	84	97	70	57	214	*	247	106	286
AQ12	238	590	165	467	90	86	82	63	62	167	*	50	88	95
QI1												59	94	
QI2												60	116	

* No data available

TABLE 4.2.6
(Concluded)

	ARITHMETIC AVERAGE												FY91		
	FY88				FY89				FY90						
	Spring	Summer	Fall	Winter	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
AQ1	43	59	63	68	41	50	61	43	34	51	*	59	41	46	
AQ2	60	80	79	85	48	72	89	51	40	72	*	56	48	74	
AQ3	40	53	46	40	29	47	41	27	30	58	*	32	31	51	
AQ4		51	42	35	29	46	39	23	26	45	*	31	31	48	
AQ5	41	43	44	60	34	43	44	41	28	46	*	66	39	45	
AQ5B	40	43	45	56	32	43	43	40	28	47	*	52	36	42	
AQ6	37	42	38	43	29	45	40	26	73	78	*	35	33	45	
AQ7	42	42	46	46	31	47	43	30	28	49	*	43	35	43	
AQ8	43	43	41	44	32	48	38	28	29	51	*	35	34	48	
AQ9	40	41	41	40	28	40	38	25	27	43	*	31	31	38	
AQ10	97	96	74	45	51	45	29	24	*	37	36	44			
AQ11	60	104	135	195	56	45	42	26	28	51	*	38	51	65	
AQ12	47	110	69	100	37	45	37	23	27	46	*	36	37	49	
QI1												37	52		
QI2												32	57		

* No data available

TABLE 4.2-7
PARTICULATE SOURCES WITH EMISSIONS OF 25 TPY OR MORE

County	UTM/E	UTM/N	Map #	Plant Name	Emissions (tpy)	Percent Tri-County Total
Adams	503.0	4406.2	1	PSCO Cherokee Plant	238	14.7
Adams	504.5	4405.5	2	Conoco, Inc.	141	8.7
Denver	499.8	4309.9	3	PSCO Arapahoe Plant	127	7.9
Adams	507.9	4412.2	4	Purina Mills	98	6.1
Adams	507.7	4414.8	5	Cooley Gravel Co. - 88th & Riverdale	87	5.4
Adams	505.5	4406.1	6	Boyles Galvanizing Co.	47	2.9
Adams	519.5	4409.9	7	Landfill, Inc.	46	2.8
Adams	508.0	4411.0	8	Mobile Premix	42	2.6
Adams	513.0	4420.2	9	Cooley Gravel Co. - 132nd & Nome	32	2.0
Adams	505.3	4405.7	10	Fast Construction Co.	32	2.0
Adams	501.1	4418.9	11	American Fertilizer & Chem.	31	1.9
Adams	500.9	4404.0	12	South Dakota Cement	31	1.9
Denver	499.6	4389.8	13	Robinson Brick & Tile	30	1.9
Denver	500.1	4402.6	14	Brannan Sand & Gravel - 41st & Fox	29	1.8
Arapahoe	520.0	4395.6	15	US Govt. Buckley Air Base	28	1.7
Adams	512.7	4420.5	16	Brannan Sand & Gravel - 132nd & Nome	27	1.7
Adams	535.0	4415.0	17	Edward C. Levy	26	1.6
Adams	513.6	4408.3	18	RMA	1	0.1
TRI-COUNTY TOTALS					1,616	67.6

Source: Colorado Department of Health EISPS Inventory, May 1992.

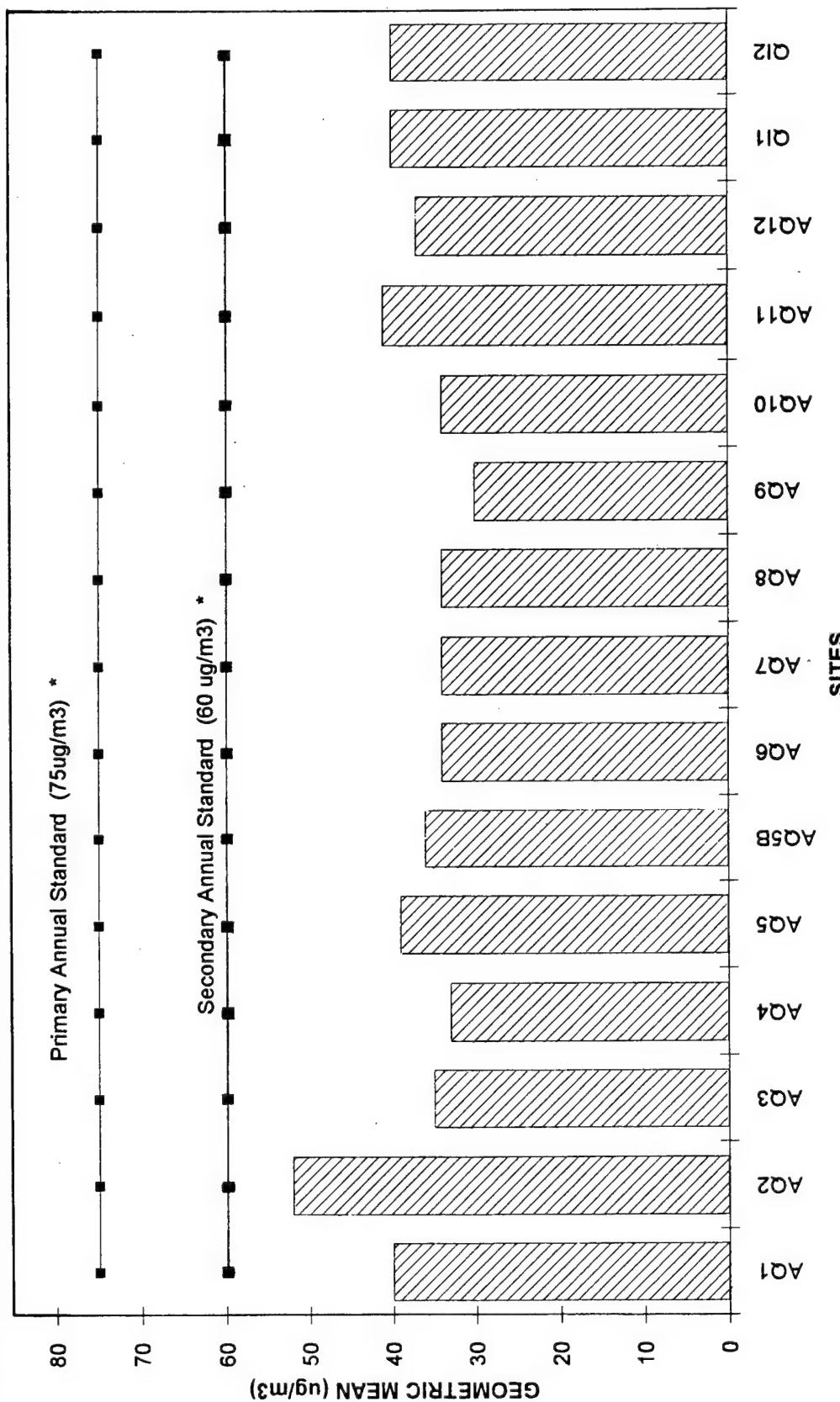
TABLE 4.2-8
DENVER METROPOLITAN AREA TOTAL SUSPENDED PARTICULATES (TSP)
(in $\mu\text{g}/\text{m}^3$)

Station	Phase 1	Phase 2-1	Phase 2-2	Phase 3	Phase 4 (FY90)	Phase 5 (FY91)
GEOMETRIC MEANS						
Adams City	87.3	103.0	61.2	71.0	66.8	73.0
414 14th Street	83.7	137.4	--	--	*	*
CAMP/2105 Broadway	107.9	192.2	132.2	98.9	100.8	109.6
1050 S. Broadway	74.1	135.2	93.7	63.4	66.6	52.4
208 3rd Street	62.9	62.7	57.0	90.2	*	*
4857 S. Broadway	64.4	84.9	--	--	*	*
24-HOUR MAXIMUM VALUES						
Adams City	283.0	244.0	85.0	131.0	206.0	228.0
414 14th Street	242.0	183.0	--	--	*	*
CAMP/2105 Broadway	260.0	472.0	256.0	149.0	363.0	563.0
1050 S. Broadway	162.0	278.0	162.0	100.0	287.0	177.0
208 3rd Street	153.0	179.0	144.0	385.0	*	*
4857 S. Broadway	152.0	94.0	--	--	*	*

* Samples are no longer collected at this station.

Annual geometric mean standard is $75 \mu\text{g}/\text{m}^3$.
 Maximum 24-hour standard is $150 \mu\text{g}/\text{m}^3$.

Phase 1 is from March 22 to December 12, 1988.
 Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.
 Phase 2, Stage 2 is from February 16 to May 5, 1989.
 Phase 3 is from May 6 to September 30, 1989.
 Phase 4 is from October 1, 1989 through September 30, 1990.
 Phase 5 is from October 1, 1990 through September 30, 1991.

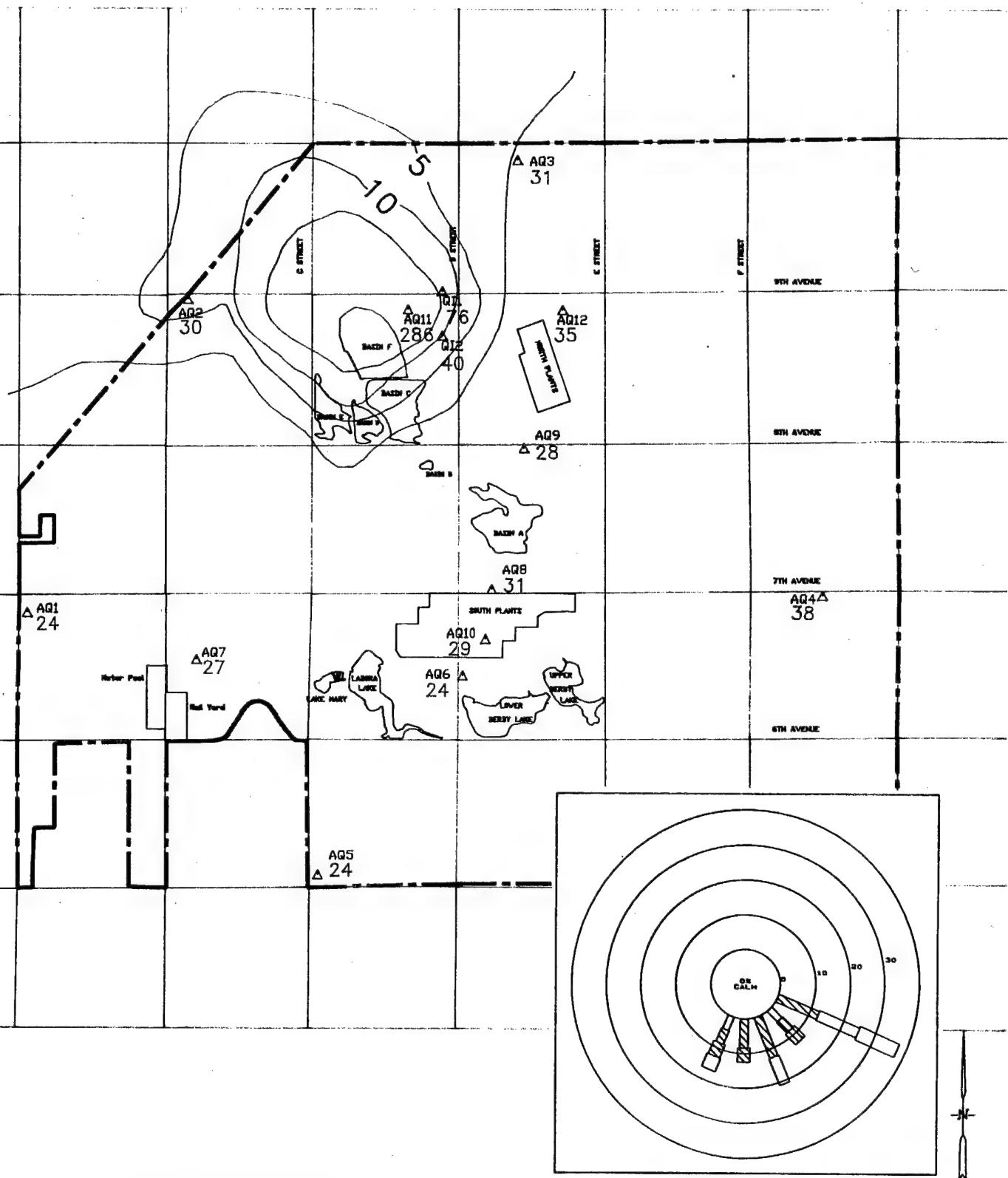


* These standards have been superseded by ambient air quality standards for PM10, but are presented to maintain a consistent comparative basis with previous monitoring years.

Job No. :	22787E
Prepared by :	T.R.H.
Date :	9/17/92

CMP TOTAL SUSPENDED PARTICULATE RESULTS FOR FY91





AQ12 Comprehensive Monitoring Location

24 Hour Maximum ($\mu\text{g}/\text{m}^3$)

Source: Basin F

5000 0 5000 10000
SCALE Feet



TSP Results and x/Q Dispersion for 09/09/91
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb DATE : 5/5/92

PROJECT NO:

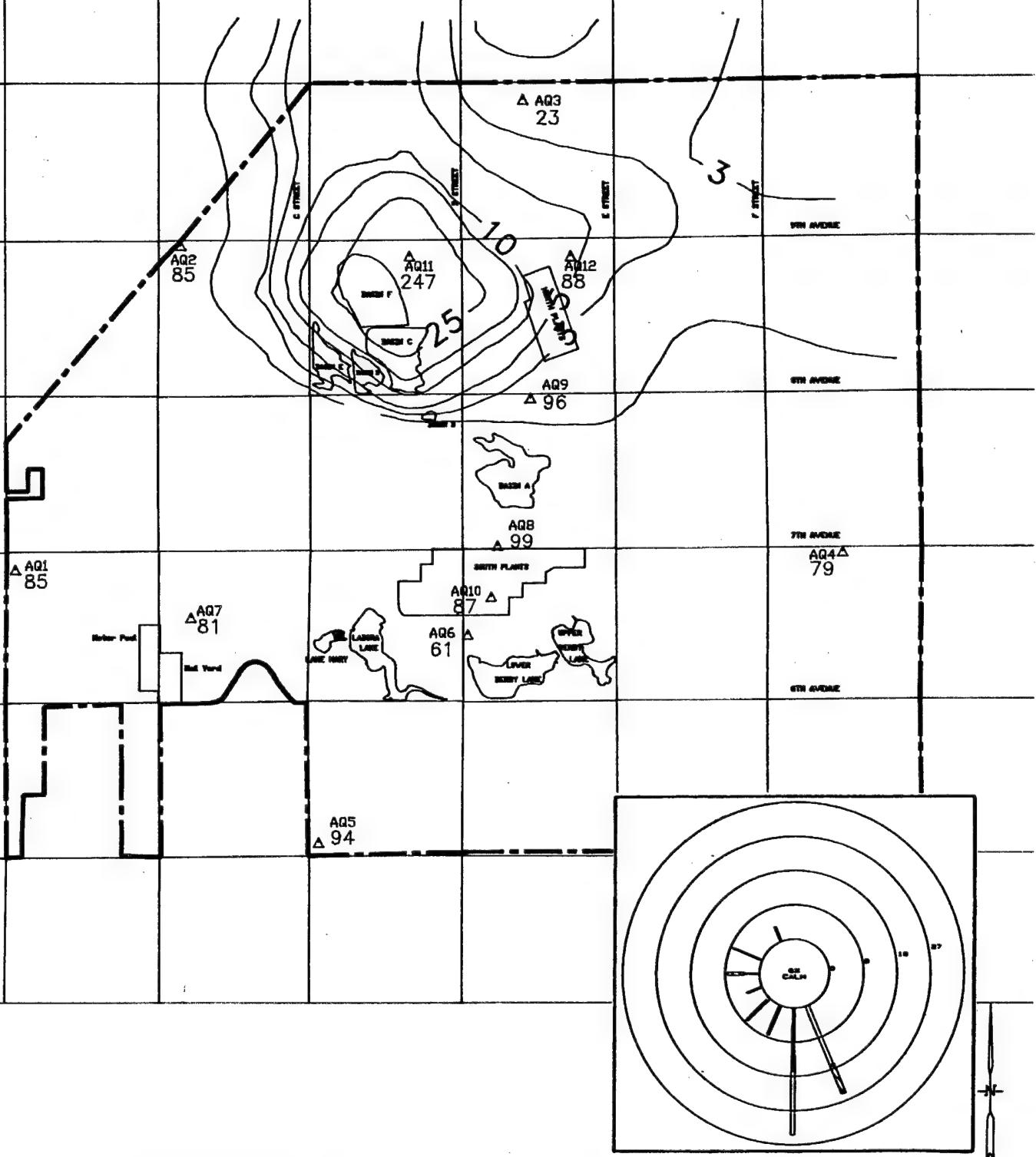
FIG. NO :

CHKD BY : DATE :

22787E

4.2-2

RMA4222



AQ12 Comprehensive Monitoring Location
24 Hour Maximum ($\mu\text{g}/\text{m}^3$)
Source: Basin F

5000 0 5000 10000
SCALE Feet



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

TSP Results and x/Q Dispersion for 03/19/91
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

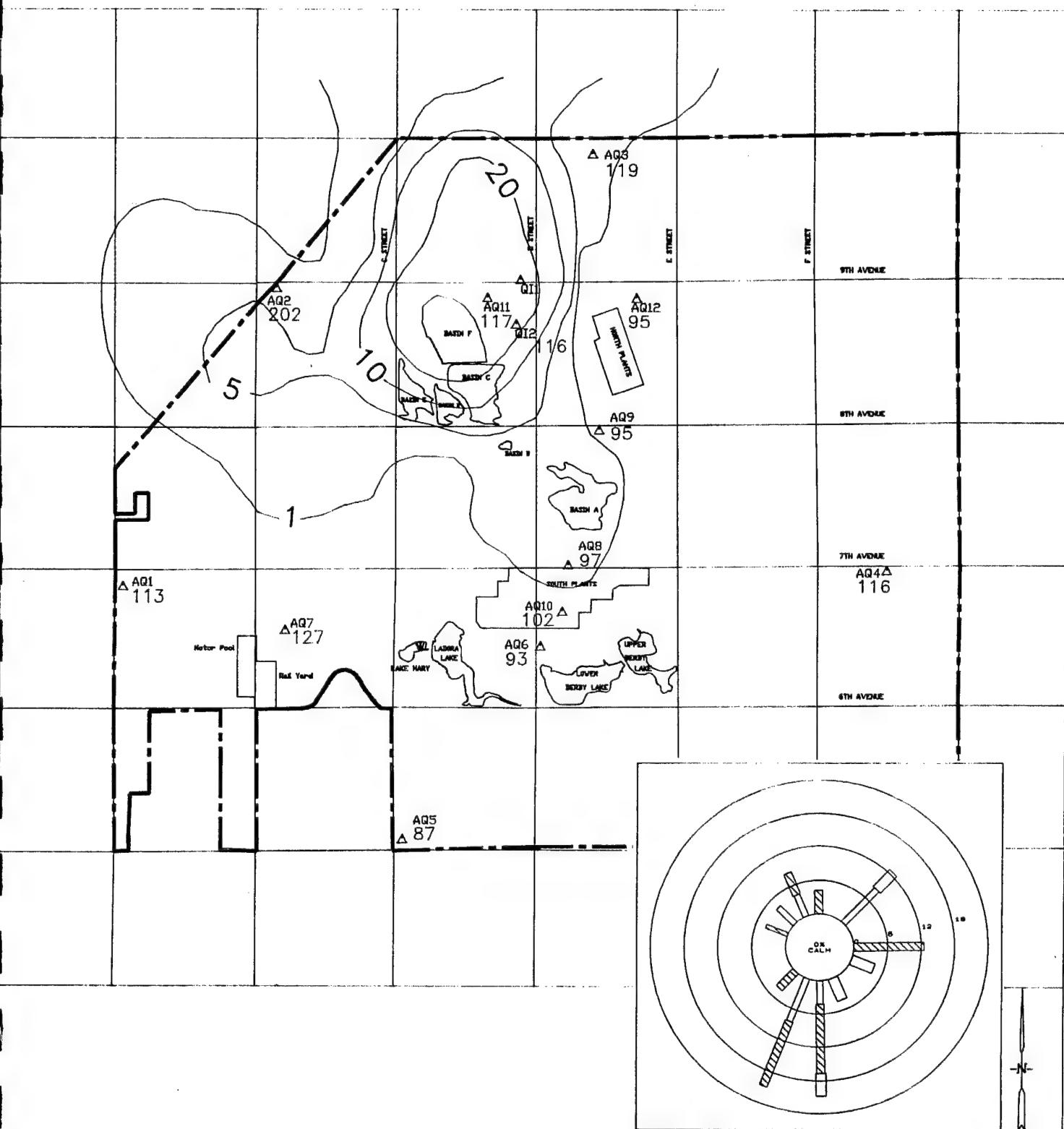
DRWN BY : dwb DATE : 5/5/92

PROJECT NO: FIG. NO :

RMA4223

CHKD BY : . DATE : .

22787E 4.2-3



AQ12 Comprehensive Monitoring Location
24 Hour Maximum ($\mu\text{g}/\text{m}^3$)
Source: Basin F

5000 0 5000 10000
SCALE Feet



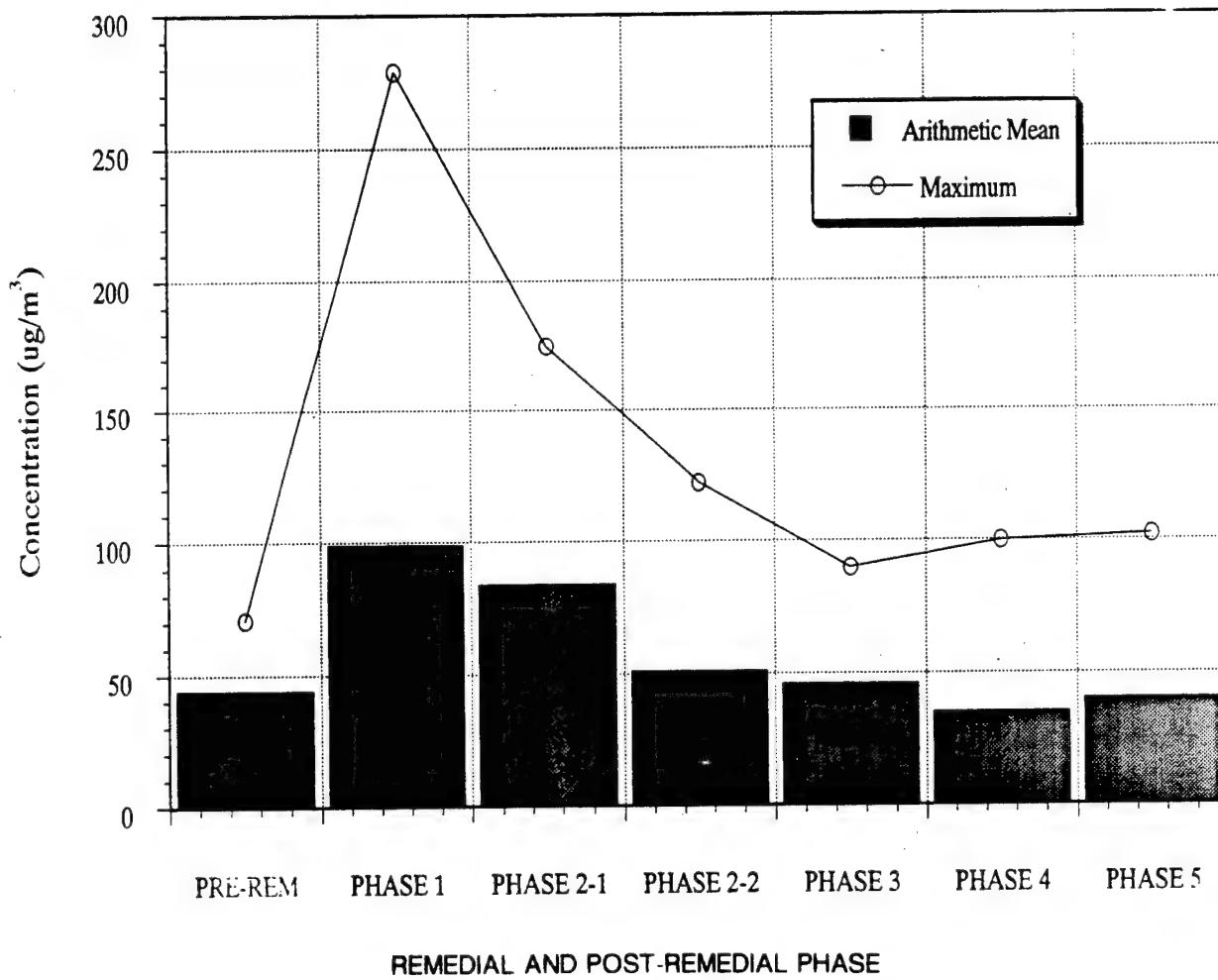
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

TSP Results and x/Q Dispersion for 09/27/91
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

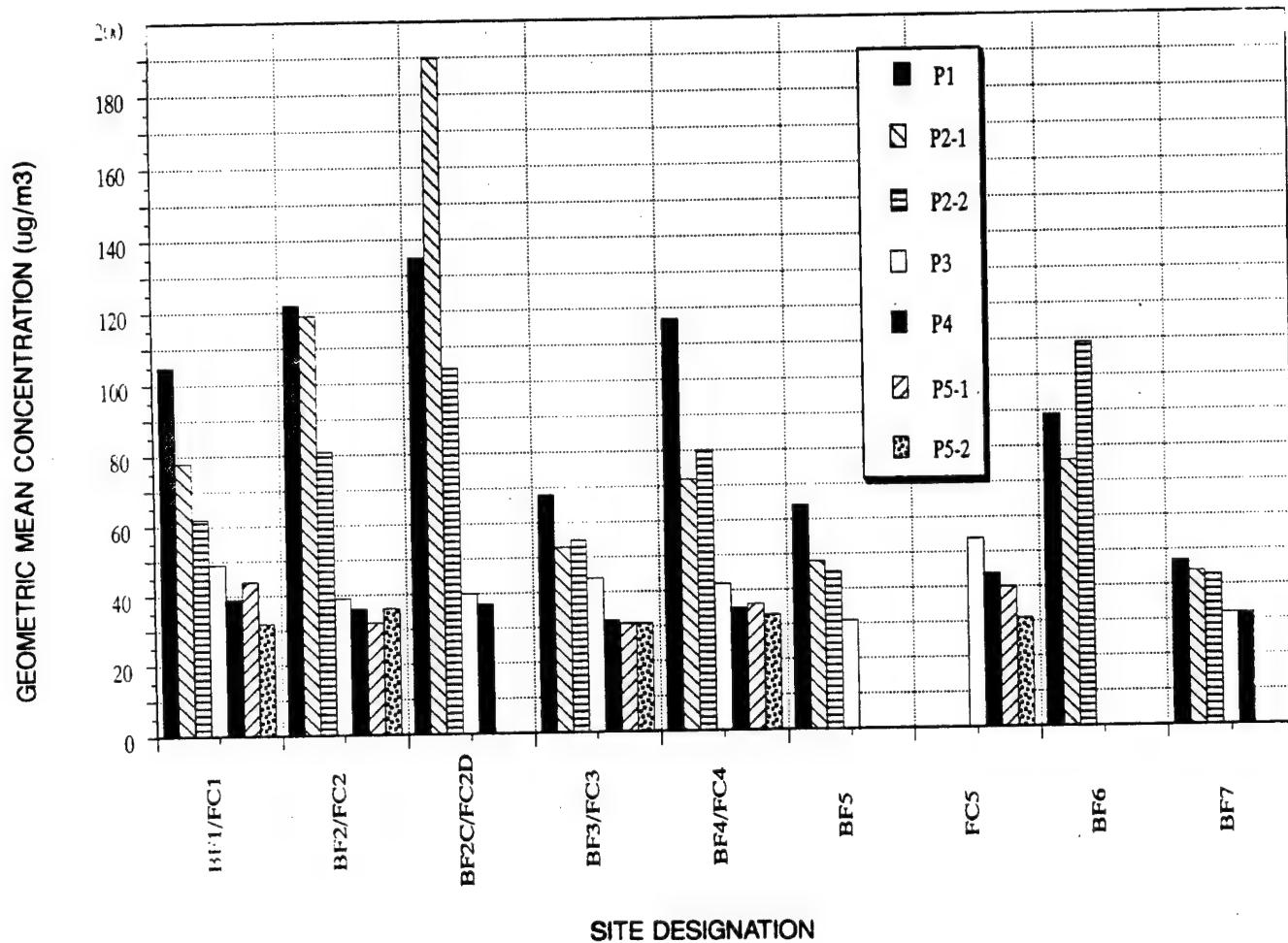
DRWN BY : dwb	DATE : 5/5/92	PROJECT NO: 22787E	FIG. NO : 4.2-4
CHKD BY : .	DATE :		



Job No. :	22787E
Prepared by :	T.R.H.
Date :	9/4/92

TSP CONCENTRATIONS AT AQ10
DURING REMEDIAL AND
POST-REMEDIAL PHASES



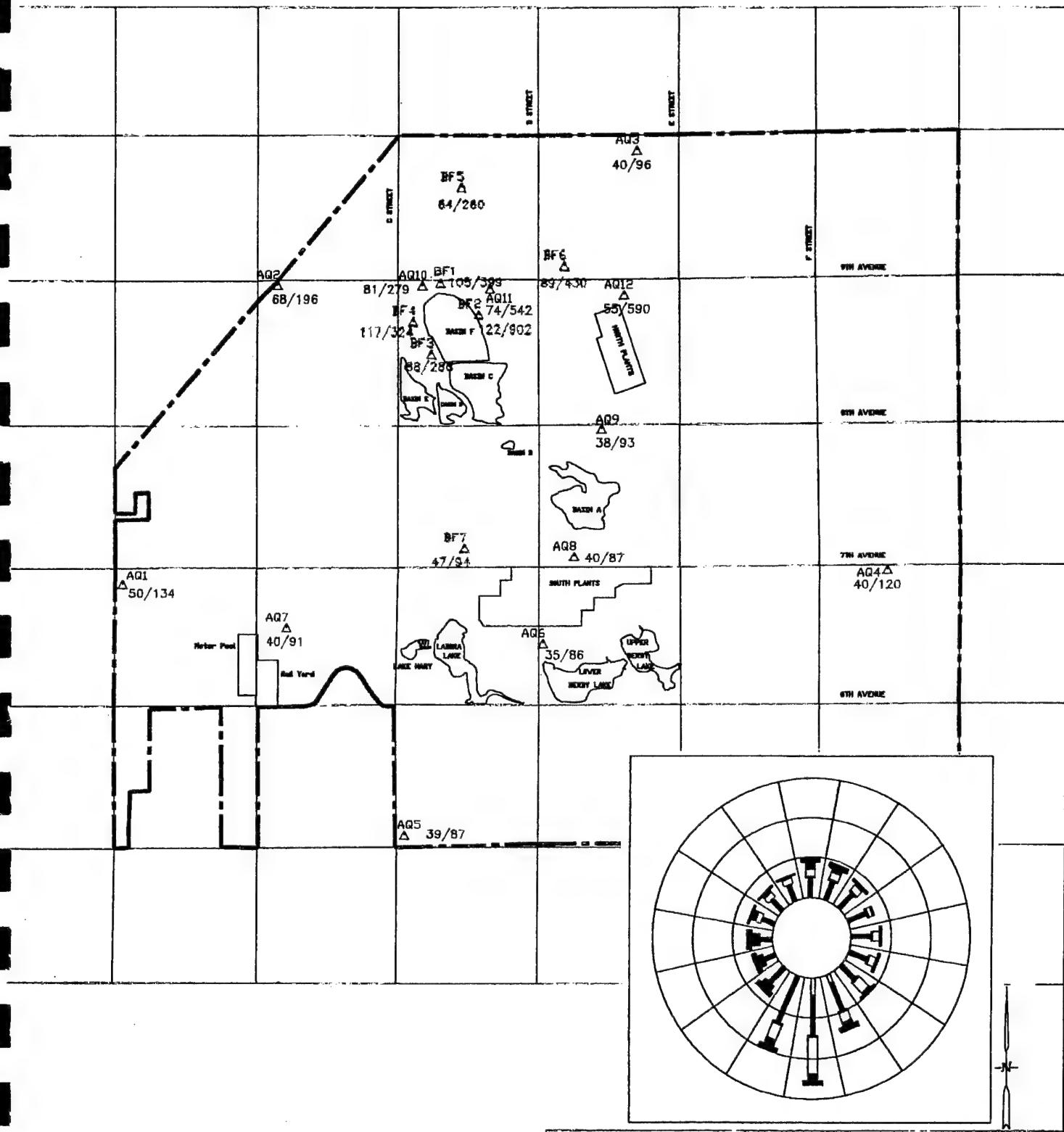


Job No. :	22787E
Prepared by :	T.R.H.
Date :	9/4/92

BASIN F/IRA-F TSP RESULTS BY
REMEDIAL AND POST-REMEDIAL PHASE



FIG. 4.2-6



LEGEND

- BF6** **BASIN F**
AQ5 **Monitoring Location**
AQ5 **Comprehensive Monitoring Location**
Geometric mean / 24 Hour Maximum (ug/m³)

5000 0 5000 10000
SCALE Feet



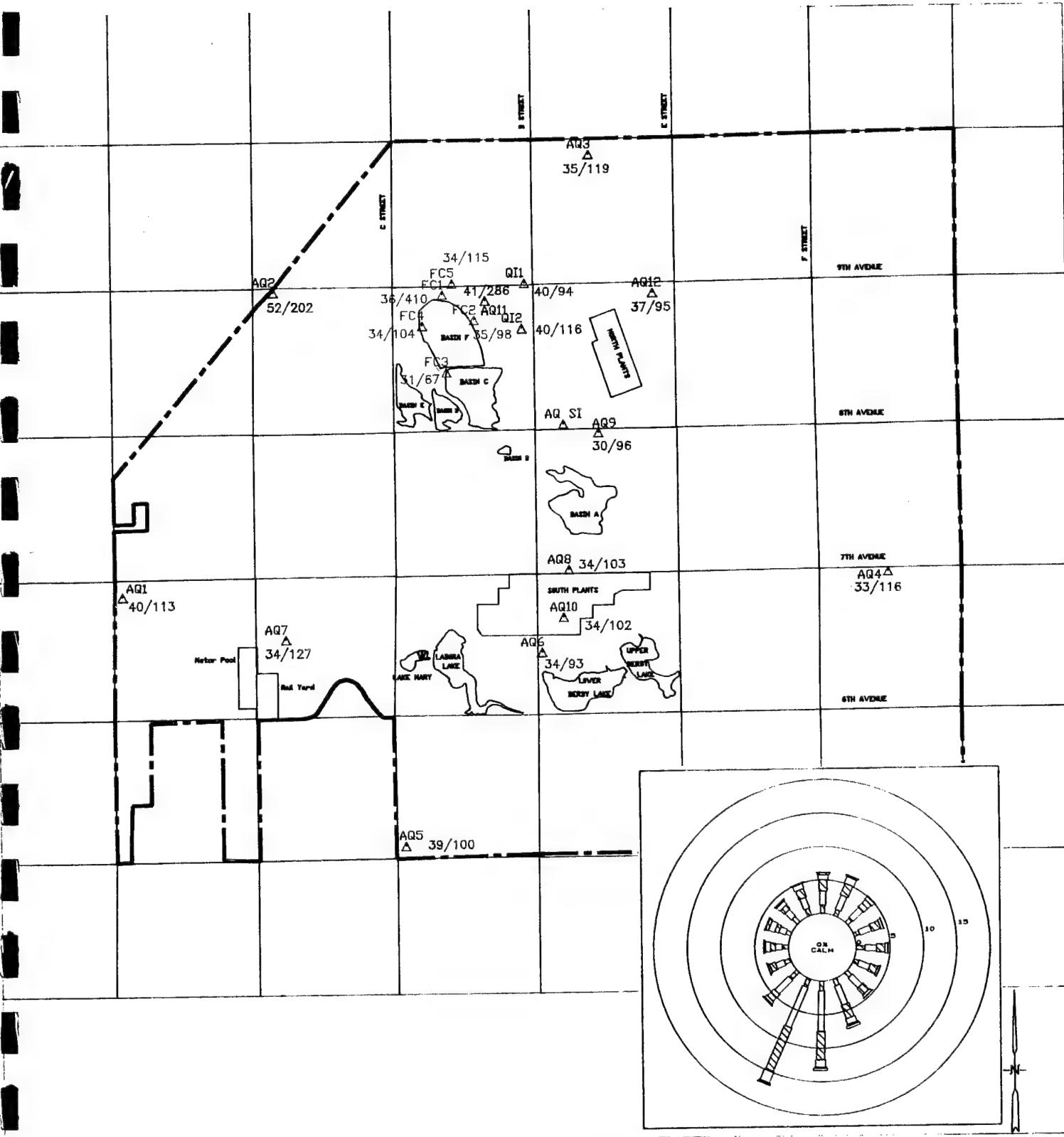
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

Composite TSP Analysis for Phase 1 CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	dwb	DATE : 5/5/92	PROJECT NO:	FIG. NO :
CHKD BY :	.	DATE :	22787E	4.2-7



LEGEND

- FC3** △ CMP FC Sites (Formerly IRA-F)
- AQ5** △ Comprehensive Monitoring Location
- Geometric mean / 24 Hour Maximum ($\mu\text{g}/\text{m}^3$)

5000 0 5000 10000
SCALE Feet



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

Composite TSP Analysis for Phase 5 CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

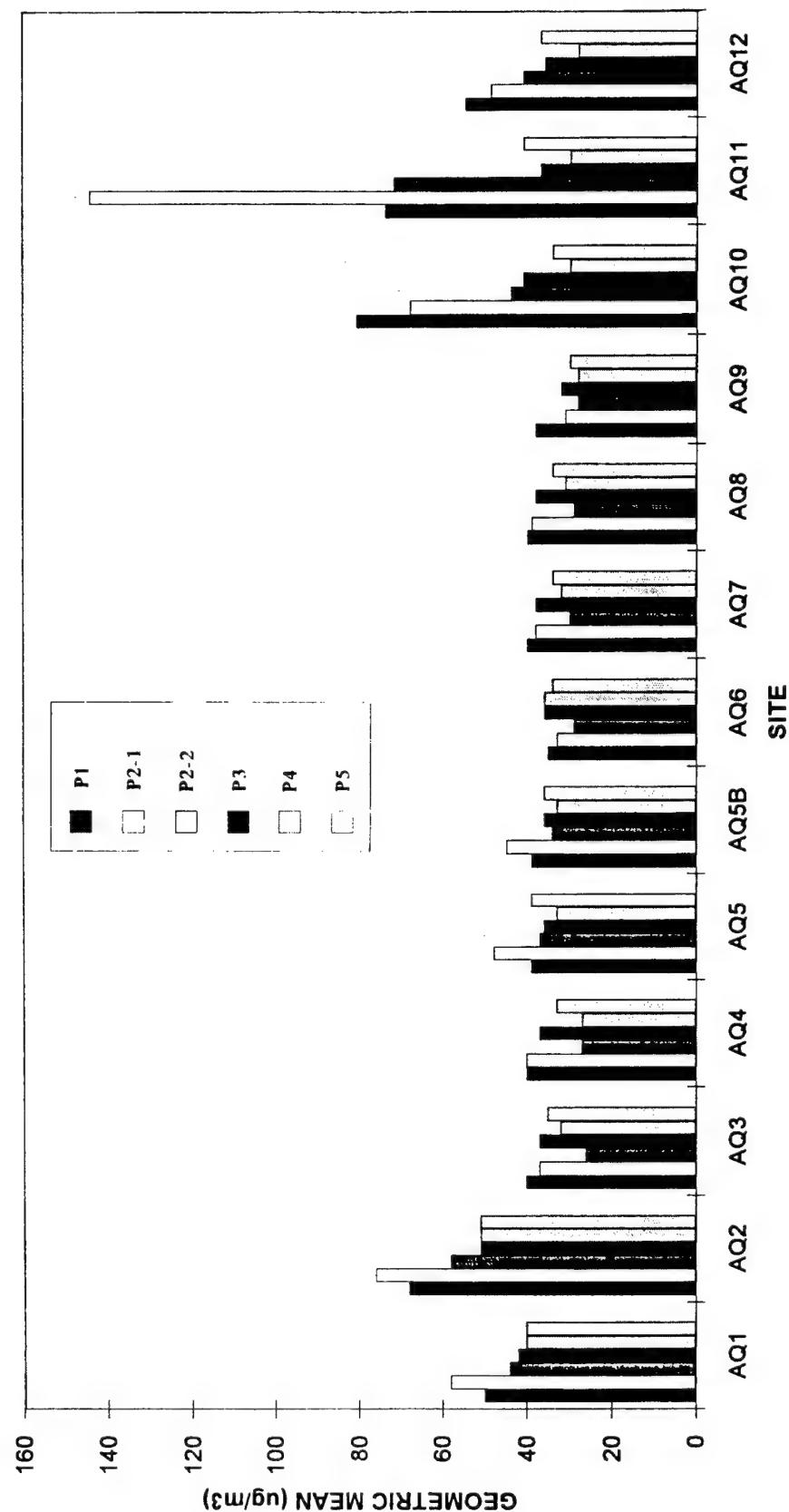
Rocky Mountain Arsenal

RMA4238

DRWN BY :	dwb	DATE : 5/5/92
CHKD BY :	.	DATE :

PROJECT NO:
22787E

FIG. NO :
4.2-8

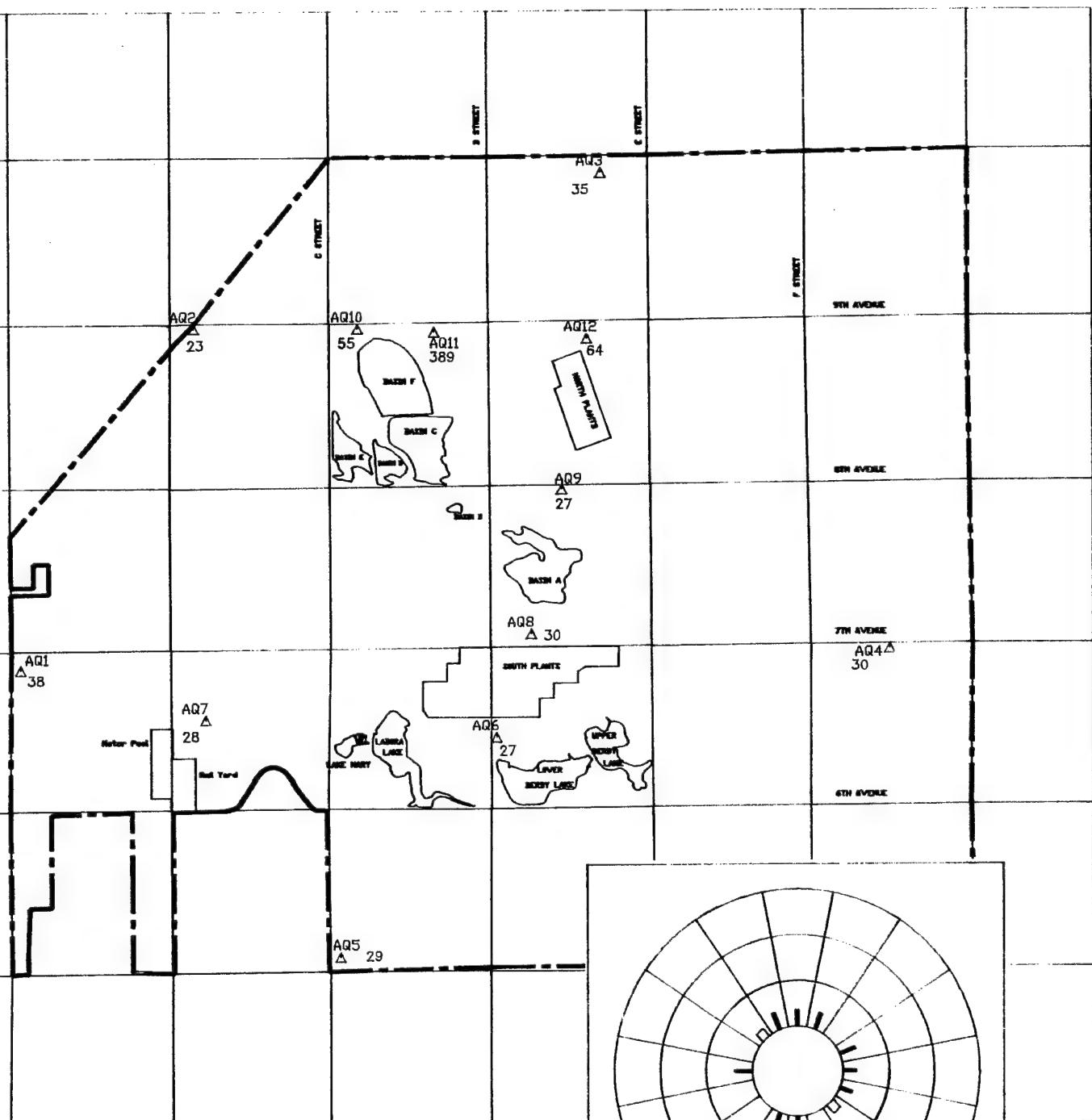


Job No. :	22787E
Prepared by :	T.R.H.
Date :	9/17/92

GEOMETRIC MEAN TSP
CONCENTRATION BY PHASE
FOR EACH CMP SITE



FIG. 4.2-9



LEGEND

AQ5 Comprehensive Monitoring Location

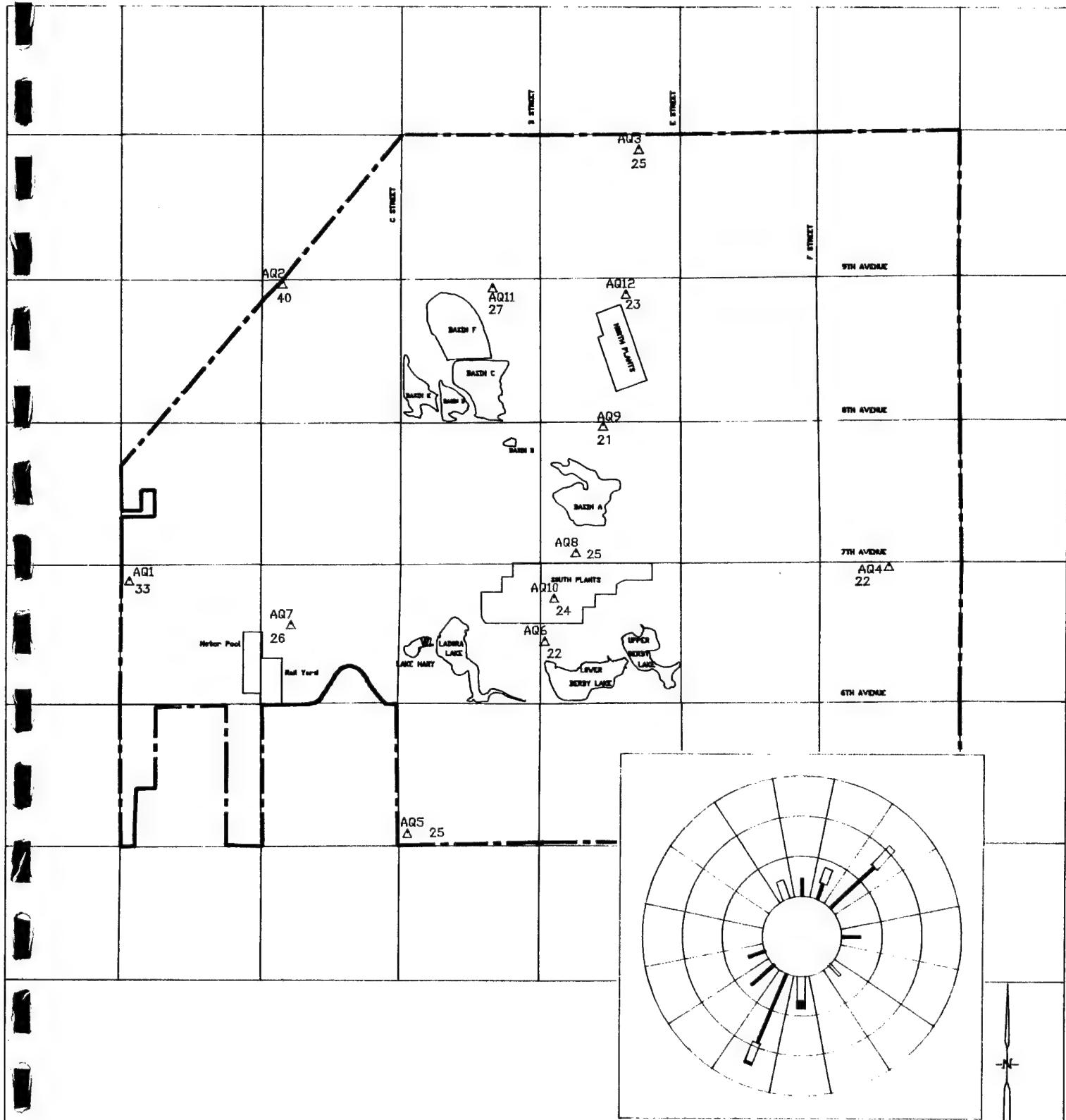
24 HR Values ($\mu\text{g}/\text{m}^3$)



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

Composite TSP Analysis for 09/24/88
CMP Air Quality Data Rocky Mountain Arsenal
U.S. Program Manager Rocky Mountain Arsenal

DRWN BY : dwb	DATE : 5/5/92	PROJECT NO: 22787E	FIG. NO : 4.2-10
CHKD BY : .	DATE : .		



LEGEND

AQ5 Comprehensive Monitoring Location

24 HR Values ($\mu\text{g}/\text{m}^3$)



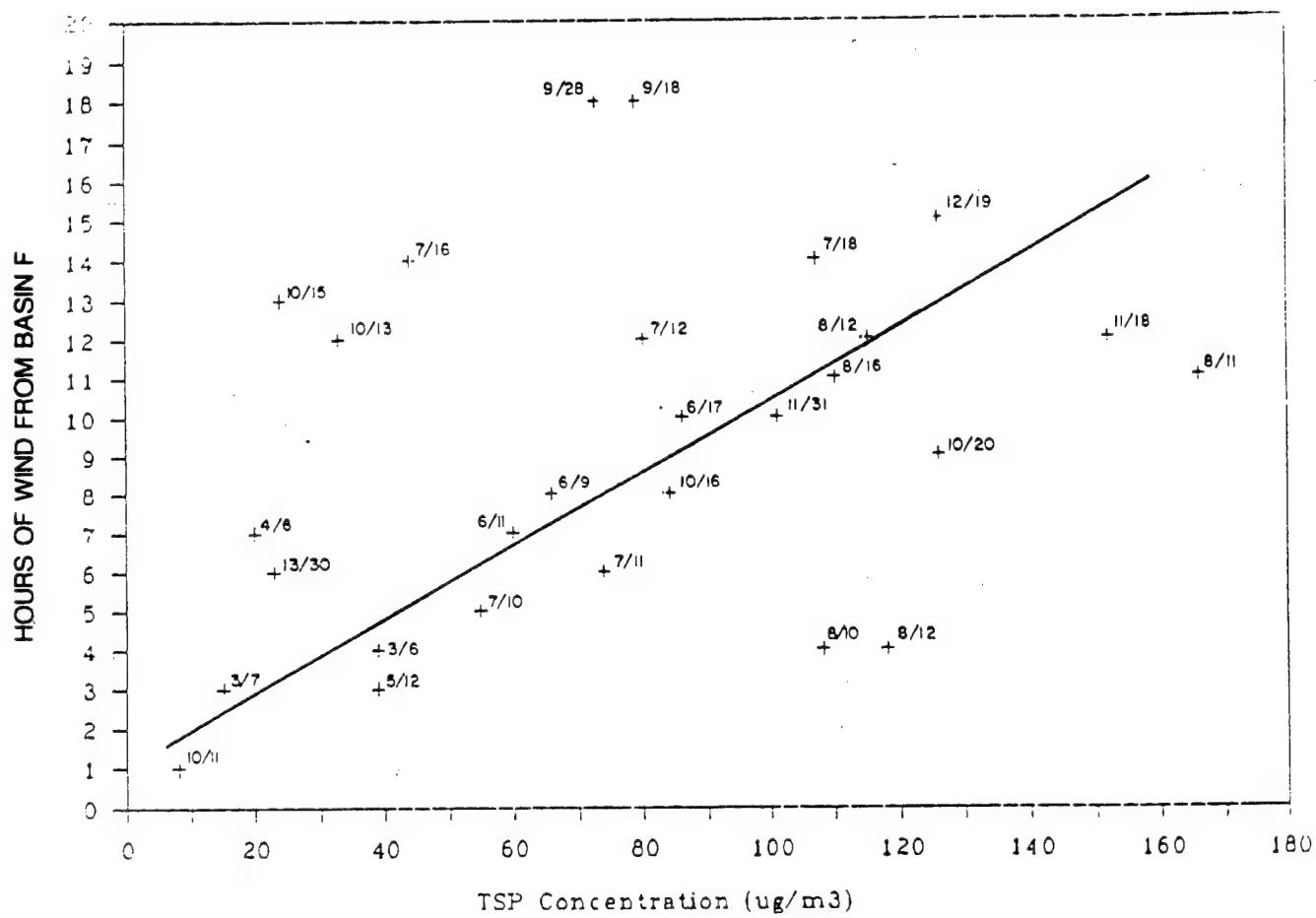
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

TSP Results for 09/26/90
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

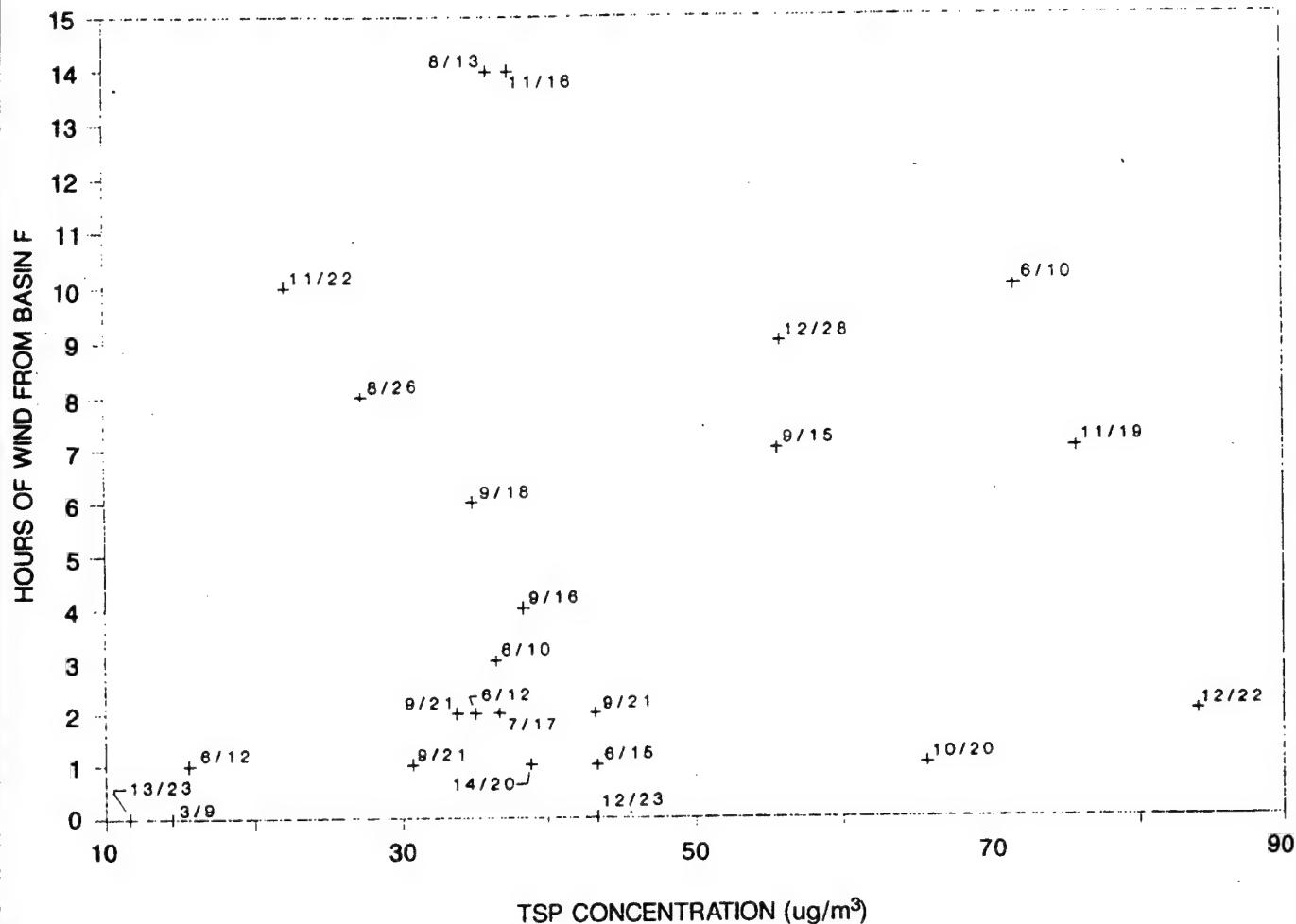
DRWN BY :	dwb	DATE :	5/5/92	PROJECT NO:	
CHKD BY :	.	DATE :	.	22787E	FIG. NO : 4.2-11



Job No. :	22787E
Prepared by :	T.R.H.
Date :	9/4/92

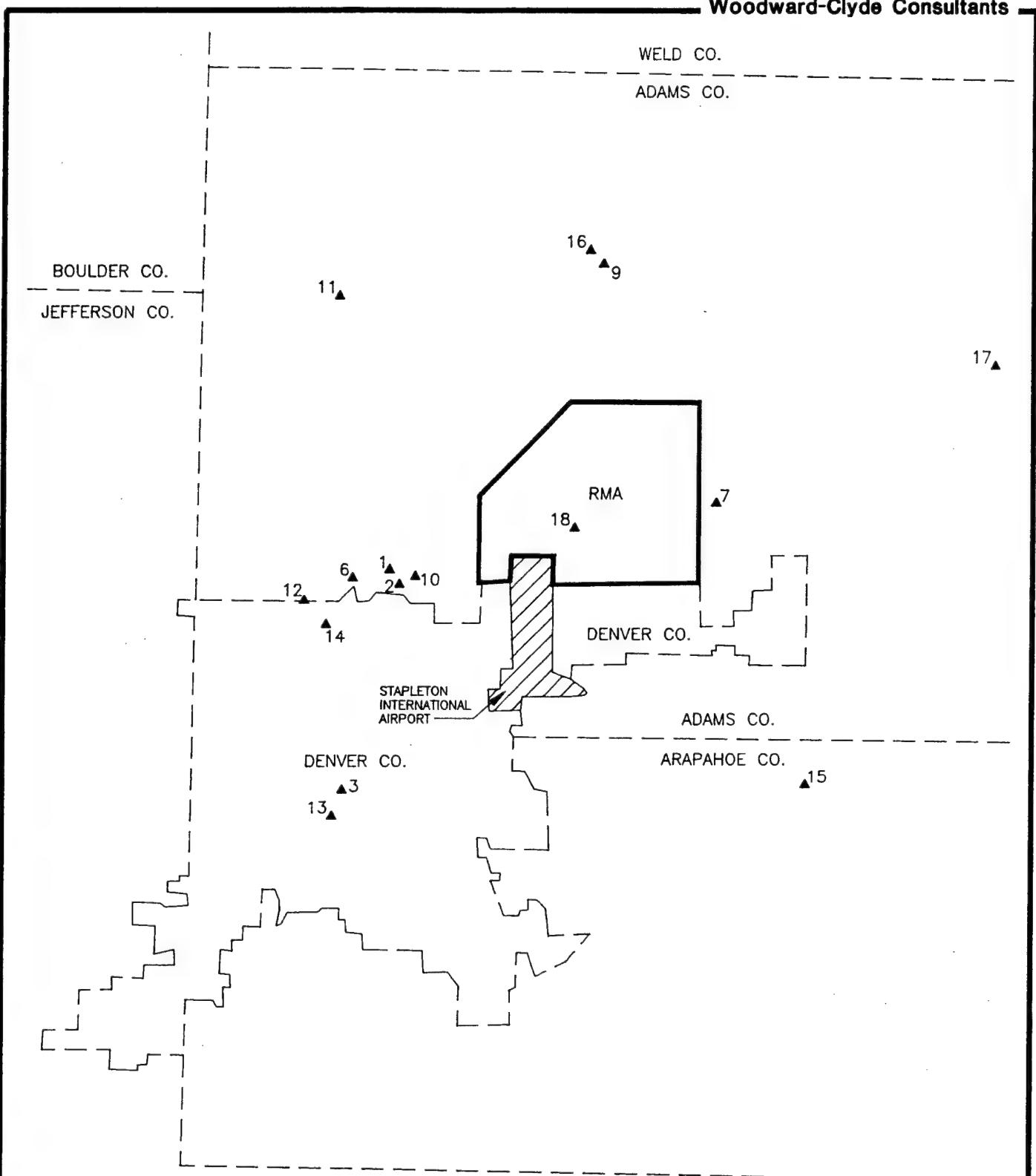
SITE AQ11 TSP CONCENTRATIONS VS.
HOURS OF WIND FROM DIRECTION
OF BASIN F - PHASE 1





Job No. :	22787E
Prepared by :	T.R.H.
Date :	9/4/92

SITE AQ11 TSP CONCENTRATION VS.
HOURS OF WIND FROM DIRECTION
OF BASIN F - PHASE 3

LEGEND▲²⁰ APPROXIMATE LOCATION OF SOURCE

— — — APPROXIMATE COUNTY LINE



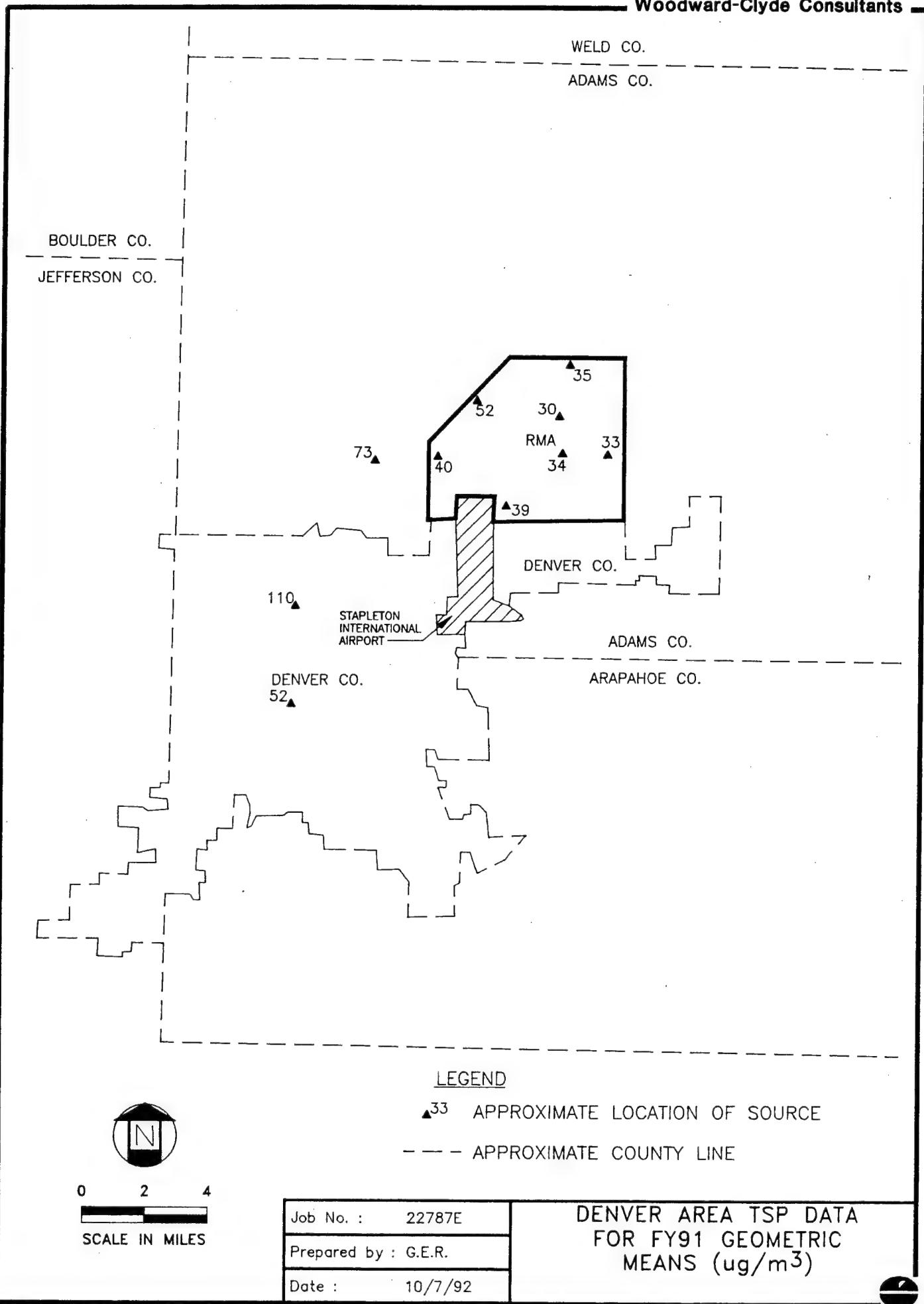
0 2 4

SCALE IN MILES

27874614

Job No. :	22787E
Prepared by :	G.E.R.
Date :	10/7/92

PARTICULATE SOURCES WITH
Emissions of 25 TPY OR
MORE IN RMA VICINITY



4.3 RESPIRABLE PARTICULATE MATTER

4.3.1 PM-10 Monitoring Program

Respirable particulate matter, designated as "PM-10," are those particles in air with aerodynamic diameters less than 10 microns (10^{-6} meters). These particles are typically small enough to be inhaled deep within the lungs. As a continuation of the program from FY90, PM-10 was monitored at six individual sites (AQ1, AQ2, AQ3, AQ5, AQ9, and AQ10) during the FY91 monitoring period. AQ10 was initially established as a portable monitoring station downwind of the South Plants subdrain area during the last month of FY90 and continued as a permanent site during FY91. A collocated monitor at Site AQ5 (designated as AQ5C) was also a continuation from the previous monitoring year. Two additional monitoring sites were established in April near the quench incinerator and are designated as Q11 and Q12. A summary of sampling frequency and data recovery for FY91 PM-10 monitoring is displayed in Table 4.3-1. Sampling was also conducted at FC1 near Basin F, continuing the collection of data initiated at this site during FY90. Sampling at FC3 was discontinued in April 1991 as QI1 and QI2 were established.

The average (arithmetic mean) and 24-hour maximum concentrations for the CMP FY91 PM-10 program are presented in Table 4.3-2. As shown in Section 2, Table 2.1-1, the PM-10 federal and state standards are arithmetic mean values of $50 \mu\text{g}/\text{m}^3$ on an annual basis and $150 \mu\text{g}/\text{m}^3$ for a 24-hour period. For FY91, PM-10 did not exceed either the annual or 24-hour ambient air quality standards at any of the monitored sites on the RMA property.

The FY91 PM-10 annual arithmetic mean values were little changed from those obtained during the FY90 monitoring period. A summary of annual arithmetic mean PM_{10} concentrations for FY91 is presented graphically in Figure 4.3-1. The 24-hour maximum values, however, were all lower than those obtained the previous year with the exception of Site AQ9. The FY91 PM-10 annual arithmetic mean and 24-hour maximum values were considerably lower than FY89 levels at all five permanent RMA monitoring sites (AQ1, AQ2, AQ3, AQ5 and AQ9) similar to FY90 PM-10 results.

Highest concentrations were measured at the boundaries of the Arsenal. AQ1 measured the highest annual average concentration of $26 \mu\text{g}/\text{m}^3$ during FY91. AQ2, at the northwestern boundary and closest to Commerce City traffic, measured the second highest annual average of $25 \mu\text{g}/\text{m}^3$, the same as in FY90, compared to a value of $33 \mu\text{g}/\text{m}^3$ in FY89. The highest 24-hour level was $92 \mu\text{g}/\text{m}^3$ at AQ9 during FY91 compared to a maximum 24-hour concentration of $90 \mu\text{g}/\text{m}^3$ at AQ10 during FY90 and a maximum 24-hour concentration of $168 \mu\text{g}/\text{m}^3$ in FY89 at AQ1.

In general, the highest PM-10 concentrations occurred in the fall and winter periods at most sites. Since there were no significantly high episodes of PM-10 concentrations in FY90 or FY91, the monthly differences were not as striking as in FY88 and FY89. The highest monthly concentrations were reported in September when $38 \mu\text{g}/\text{m}^3$ was measured at AQ2 and $39 \mu\text{g}/\text{m}^3$ was measured at AQ9. The highest concentration on a single day occurred on September 3, 1991 at AQ9 with a 24-hour PM-10 concentration of $92 \mu\text{g}/\text{m}^3$. PM-10 concentrations at the other RMA sites were elevated, but were less than half of the AQ9 value (i.e., second highest PM-10 concentration on this date was $45 \mu\text{g}/\text{m}^3$ at AQ2). Since the $92 \mu\text{g}/\text{m}^3$ at AQ9 is also much greater than the measured TSP concentration of $31 \mu\text{g}/\text{m}^3$ on the same date, this value may be anomalous and not actually indicative of on-site conditions conducive to high PM_{10} concentrations. The second highest 24-hour value for PM_{10} was measured as $50 \mu\text{g}/\text{m}^3$ at AQ1 on February 5, 1991. This elevated PM_{10} occurrence is better substantiated by measured PM_{10} concentrations at the other RMA monitoring sites and by observed meteorological conditions. Above average PM_{10} concentrations were also measured at AQ5 on this date. A summary of measured PM_{10} concentrations on this date, observed meteorological conditions and the dispersion pattern that would result from Basin F being the primary emissions source is graphically presented in Figure 4.3-2. Winds were primarily from the south-southwest, from the direction of Denver, at an average wind speed of 7.5 miles per hour. Maximum gusts were up to 14 miles per hour, suggesting that strong winds were not a factor in disturbing exposed soil surfaces within the immediate area. The elevated PM_{10} concentrations at the southern and western boundaries indicated that PM_{10} impacts were most likely from metropolitan Denver on this date. Measured PM_{10} concentrations at metropolitan Denver monitoring stations ranged from 51 to $92 \mu\text{g}/\text{m}^3$ and the downtown Denver monitoring station (CAMP) measured a maximum 24-hour TSP concentration of $284 \mu\text{g}/\text{m}^3$.

4.3.2 Basin F PM-10 Impacts

4.3.2.1 CMP Data

Since an increased emphasis has been placed during recent years on the adverse health effects of respirable particulate (PM_{10}) as compared to TSP, PM_{10} monitoring has occurred during both remedial and post-remedial phases. Table 4.3-3 presents PM-10 concentrations for the various phases of the remediation and post-remediation periods.

No violations of the PM_{10} ambient standards occurred during the Phase 1 period at AQ1. Maximum PM_{10} concentrations occurred during the Phase 2, Stage 1 period (remedial landscaping/hauling), which were most likely attributed to the winter seasonal impacts over RMA from metropolitan Denver. The highest arithmetic average concentration (53 $\mu g/m^3$) for the 2-month period (December 13, 1988, through February 15, 1989) occurred at AQ1 at the western RMA boundary. The highest 24-hour PM-10 concentration of 168 $\mu g/m^3$ also occurred at AQ1; this was an exceedance of the 24-hour ambient standard of 150 $\mu g/m^3$. As noted in the FY89 report, this maximum PM_{10} concentration occurred on February 9, 1989, when metropolitan Denver and all Arsenal stations were exposed to the highest PM-10 concentrations in several years. During the Phase 5 post-remedial period, PM-10 levels were consistently low across the Arsenal, ranging from an average value of 18 $\mu g/m^3$ at AQ3 to 26 $\mu g/m^3$ at AQ1. The cessation of remedial activity may also have had a minor influence in decreasing PM-10 concentrations, particularly when comparing Phase 5 to Phase 2, Stage 1 conditions.

Since the CMP did not measure PM-10 immediately adjacent to Basin F during remedial operations, PM_{10} impacts from Basin F operations are difficult to identify. PM-10 concentrations monitored at AQ10 and AQ11 would likely be elevated since high TSP concentrations were monitored during the Phase 1 and Phase 2 periods (see Table 4.2-3). A study conducted over the 43-month CMP monitoring period indicated that PM-10 levels ranged from 37 to 62 percent of TSP levels. Figures 4.3-3, 4.3-4, and 4.3-5 compare sequential TSP and PM-10 concentrations for AQ2, AQ5, and AQ9 during FY91. The overall PM-10 to TSP ratios are 0.41, 0.44, and 0.59 for AQ2, AQ5, and AQ9, respectively. This correlation infers that stations immediately downwind from Basin F cleanup activities (i.e., AQ10 and AQ11) would have measured higher PM-10

levels corresponding to the higher TSP levels. Station AQ2 has consistently measured the lowest ratios of PM-10 to TSP concentrations; 36 percent in 1988, 43 percent in 1989, 45 percent in 1990 and 41 percent in 1991. Because of the proximity of AQ2 to the remedial area, it received more direct impacts from Basin F. Therefore, the lower PM-10 to TSP ratios at AQ2 suggested the premise (in the FY89 Assessment Report) that remedial impacts were less for smaller particulates than for TSP. However, AQ2 again had the lowest ratio during FY91, when Basin F remedial impacts were minimal, similar to previous post-remedial phases. As speculated in the FY90 report, a possible explanation for the lower ratio would be that dust from Commerce City traffic impacts AQ2 and contains a higher percentage of heavier particles, resulting in a lower fraction of PM-10 within TSP.

In addition to source influences, seasonal and climatological conditions affected PM-10 monitoring results, as well. Table 4.3-4 shows seasonal PM-10 data averaged over the entire CMP. The highest average concentrations occurred in the fall and winter, coinciding with inversion or "brown cloud" conditions over metropolitan Denver. Considerable variability exists between seasonal maximum levels, depending on source influences, seasonal and climatological influences, and unique meteorological events. Table 4.3-5 shows seasonal PM-10 results for 14 consecutive quarters of the CMP from the spring of 1988 to the summer of 1991. Higher PM-10 concentrations were measured during the winter of FY91 than in FY90, possibly due to the greater occurrence of winter inversion impacts from metropolitan Denver. Higher average PM-10 concentrations were measured during the summer of FY91 particularly at AQ2, as a result of meteorological conditions transporting dust from metropolitan Denver area sources. In general, higher average PM-10 levels during the fall and winter periods are consistent with the greater number of inversion and "brown cloud" episodes that occurred in metropolitan Denver during those months. Measured PM-10 concentrations at the CMP monitoring stations are apparently not significantly impacted by remediation, except immediately adjacent and downwind of construction activities. Measured concentrations of PM-10 data collected at RMA are comparable to levels reported in rural areas of Colorado (CDH, 1989).

4.3.2.2 Basin F Data

PM-10 was not measured in the immediate vicinity of Basin F during the Basin F Interim Remedial Monitoring Program. However, because of the increased emphasis placed on PM-10, monitoring of this criteria pollutant was initiated during the IRA-F follow-on monitoring program (Phases 3, 4, and 5) to determine if any residual or post-remedial PM-10 impacts resulted from the Basin F remediation activities. The program consisted of monitoring every 12 days at FC1, downwind from Basin F and at FC3, upwind from Basin F until the end of March, 1991. Results are shown in Table 4.3-6. Twenty-four hour sequential data are provided in Appendix B.

During the Phase 5 period, FC1 measured an average concentration of $22 \mu\text{g}/\text{m}^3$, while FC3 measured an average concentration of $19 \mu\text{g}/\text{m}^3$ (excludes spring and summer months). The results of both monitoring stations were almost identical to other RMA interior monitoring sites, suggesting little or no post-remedial PM-10 impacts from the Basin F operations over the annual period.

The maximum 24-hour PM-10 concentration was $84 \mu\text{g}/\text{m}^3$ at FC1 on November 13, 1990. This high value occurred on the same date that the TSP concentration was measured at $410 \mu\text{g}/\text{m}^3$. As noted in Section 4.2.2.2, the elevated TSP and PM_{10} concentrations at FC1 were most likely due to special restoration activities on Basin F. For the most part, results from the IRA-F stations and the CMP interior stations were comparable during all of FY91 as in FY90, suggesting that any particulate impacts off the remediated Basin F were small.

4.3.2.3 Combined Basin F and CMP Data Analysis

Individual CMP and Basin F PM-10 monitoring data for the designated phases of the Basin F remedial programs assessment have been shown in Tables 4.3-3 and 4.3-6. Figures 4.3-6 and 4.3-7 depict annual average and 24-hour maximum PM-10 values for Phases 1 and 5 (remedial and postremedial periods). Wind roses depicting wind speed and direction distribution during these two monitoring phases are shown on these figures. The PM_{10} data show no apparent impact from the Basin F operation either during or after remedial activities on a regular basis. One possible exception is the high maximum

24-hour PM-10 concentrations that occurred at the station surrounding Basin F, FC1, on November 13, 1990; however, this was an anomalous event due to unique activities on Basin F. TSP mean concentrations were evenly distributed across the Arsenal with somewhat higher PM₁₀ concentrations at the RMA perimeter stations and evidence of minor PM₁₀ impacts at the quench incinerator construction site (QI1 and QI2).

Because PM-10 data were not collected immediately adjacent to Basin F during remedial activities, there is no conclusive data indicating that no PM-10 impacts resulted during the remedial program. Some elevated PM-10 concentrations were measured in conjunction with measured high TSP concentrations. The PM₁₀ concentration distribution illustrated in Figures 4.3-6 and 4.3-7 during Phase 1 and Phase 5, however, suggest that any PM-10 impacts from Basin F operations were highly localized and did not spread to the RMA boundaries.

4.3.3 Metropolitan Denver PM-10 Data

As in the case of TSP, PM-10 concentrations were higher in metropolitan Denver than they were at RMA. The distribution of PM-10 data across metropolitan Denver and the Arsenal suggest that there was an influx of PM-10 into the Arsenal from the Denver area. PM-10 annual arithmetic mean and 24-hour maximum concentrations for Denver throughout the CMP including FY91 are shown in Table 4.3-7.

During the Phase 1 remediation period, PM-10 levels were generally uniform across both the metropolitan area and the Arsenal, with the highest average concentration of 41 $\mu\text{g}/\text{m}^3$ reported at Adams City. There was no evidence of high PM-10 levels at the Arsenal interior, although PM-10 monitoring was not conducted immediately adjacent to Basin F.

During the Phase 2 (Stage 1) winter period, downtown Denver experienced a maximum average PM-10 level of 72 $\mu\text{g}/\text{m}^3$ and a maximum 24-hour value of 154 $\mu\text{g}/\text{m}^3$, while Adams City reached an average value of 73 $\mu\text{g}/\text{m}^3$ and a maximum value of 145 $\mu\text{g}/\text{m}^3$. As noted previously, several intensive winter inversion episodes contributed to these results. During this period, the Arsenal area also measured high PM-10 levels on several days with maximum concentrations at the western and southern boundaries. Interior

Arsenal sites indicated lower PM-10 concentrations, apparently less influenced by dispersion impacts from the metropolitan area.

During the Phase 2 (Stage 2), Phase 3, Phase 4, and Phase 5 periods, metropolitan Denver PM-10 levels decreased significantly, although the highest concentrations remained at downtown Denver and Adams City (in the direction of the prevailing wind flow). Figure 4.3-8 shows the distribution of PM-10 annual average values across metropolitan Denver and the Arsenal for the FY91 period. RMA values were again slightly higher at the western and southern boundaries; interior Arsenal stations reported their lowest PM-10 levels for the 43-month monitoring period during Phases 3, 4 and 5, with one exception. The monitoring station installed at AQ10 in September, 1990 measured higher average PM-10 concentrations due to the shorter monitoring period and its proximity to South Plants subdrain activity.

4.3.4 Summary of PM-10 Analysis

Strong gusty winds appeared to be conducive to higher PM-10 values at RMA, but to a much lesser extent than for TSP (at a ratio of 40 to 60 percent). The highest PM-10 readings were observed during strong atmospheric inversion conditions over metropolitan Denver. There were no violations of the annual or 24-hour PM-10 standards during FY91 at RMA. As in the case of TSP, there were potentially two principal sources of PM-10 impacting RMA and its surroundings: (1) the influx of PM-10 emissions from metropolitan Denver, and (2) remediation activity sources at RMA, especially during high wind episodes. Unlike the trends observed in TSP concentrations, PM₁₀ concentration data do not indicate a detectable increase in average PM-10 levels during the remedial activity. This observation may be the result of the lack of PM-10 monitoring stations immediately adjacent to remedial activities; however, most PM-10 remediation-generated emissions were localized and fell off significantly with distance from the activity, producing negligible off-post impacts.

TABLE 4.3-1
SUMMARY OF RMA CMP FY91 SAMPLING FOR
RESPIRABLE PARTICULATES OF LESS THAN 10 MICRONS (PM-10)

Station	Samples Scheduled	Number of Samples	Percent Recovery
AQ1	42	42	100
AQ2	42	41	97
AQ3	42	40	95
AQ5	42	37	88
AQ5C	42	42	100
AQ9	42	40	95
AQ10	42	35	83
FC1	30	28	93
QI1	31	24	77
QI2	31	25	81
PROGRAM TOTAL	386	354	92

TABLE 4.3-2
**CONCENTRATIONS OF RESPIRABLE PARTICULATES
 OF LESS THAN 10 MICRONS (PM-10) FOR CMP FY91 (in $\mu\text{g}/\text{m}^3$)**

Month	AQ1	AQ2	AQ3	AQ5	AQ5C	AQ9	AQ10	QI1	QI2
Summary of Arithmetic Mean Concentrations*									
October	#	#	#	#	#	#	#	#	#
November	#	#	#	#	#	#	#	#	#
December	#	#	#	#	#	#	#	#	#
January	38	34	20	33	32	19	24	##	##
February	34	24	20	27	28	20	22	##	##
March	20	17	11	15	15	16	15	##	##
April	19	19	15	16	18	16	14	22	16
May	30	25	17	20	19	18	23	21	19
June	24	29	21	21	21	23	25	31	27
July	20	27	18	17	17	18	20	21	24
August	20	23	15	15	16	18	16	20	28
September	36	38	27	24	25	39	27	##	22
ANNUAL	26	25	18	20	20	20	21	23	23
Summary of 24-Hour Maximum Concentrations**									
October	#	#	#	#	#	#	#	#	#
November	#	#	#	#	#	#	#	#	#
December	#	#	#	#	#	#	#	#	#
January	43	36	20	34	35	20	24	##	##
February	50	32	22	43	45	28	29	##	##
March	33	28	17	27	27	40	28	##	##
April	36	40	30	32	31	28	15	32	31
May	43	40	27	28	27	25	36	34	24
June	30	40	31	30	30	35	37	43	43
July	27	37	28	26	26	27	29	30	35
August	27	37	21	18	21	21	21	30	47

**TABLE 4.3-2
(Concluded)**

Month	AQ1	AQ2	AQ3	AQ5	AQ5C	AQ9	AQ10	QI1	QI2
September	70	77	48	40	39	92	48	##	37
ANNUAL	70	77	48	43	45	92	48	43	47

* Annual arithmetic mean standard is 50 $\mu\text{g}/\text{m}^3$.

** Maximum 24-hour standard is 150 $\mu\text{g}/\text{m}^3$.

Within contract lapse period of October 1990 through January 23, 1991.

No data collected for this period.

Note: FY91 is the period from October 1, 1990 to September 30, 1991.

TABLE 4.3-3

**CONCENTRATIONS OF RESPIRABLE PARTICULATES OF
LESS THAN 10 MICRONS (PM-10) FOR PHASES 1-5
(in $\mu\text{g}/\text{m}^3$)**

Month	AQ1	AQ2	AQ3	AQ5C/ AQ5	AQ5D/ AQ5C	AQ9	AQ10	QI1	QI2
Summary of Arithmetic Mean Concentrations*									
PHASE 1									
March		27		26			36		
April		23		19			20		
May		19		14			15		
June		24		17			15		
July		30		23			22		
August		37		25		36	25		
September									
October	38	37	34	25		27	25		
November	32	26	20	21		23	18		
December	57	50	42	36		39	37		
PHASE 2 - STAGE 1									
December	36	29	24	25		28	20		
January	44	30	24	28		30	19		
February	80	53	47	55		61	47		
PHASE 2 - STAGE 2									
February	27	18	16	18		19	14		
March	39	25	22	27		29	21		
April	25	20	18	17		18	15		
May	25	19	16	15		15	14		
PHASE 3									
May	29	26	21	22		24	19		
June	21	20	18	19		18	18		
July	26	38	25	23		21	25		
August	17	22	17	17		15	17		
September	27	26	26	23		23	22		

TABLE 4.3-3
(Continued)

Month	AQ1	AQ2	AQ3	AQ5C/ AQ5	AQ5D/ AQ5C	AQ9	AQ10	QI1	QI2
PHASE 4									
October	39	40	32	29	29	28			
November	28	25	22	20	20	18			
December	20	22	15	20	20	18			
January	22	21	16	24	24	12			
February	22	32	24	26	26	23			
March	15	14	12	13	11	12			
April	17	17	14	18	14	13			
May	18	17	14	15	15	16			
June	23	28	21	22	21	22			
July	17	20	20	12	15	15			
August	26	28	22	22	21	21			
September	29	31	26	25	25	26	36		
PHASE 5 - STAGE 1									
October	#	#	#	#	#	#	#	#	#
November	#	#	#	#	#	#	#	#	#
December	#	#	#	#	#	#	#	#	#
January	#	#	#	#	#	#	#	#	#
PHASE 5 - STAGE 2									
January	38	34	20	33	32	19	24	##	##
February	34	24	20	27	28	20	22	##	##
March	20	17	11	15	15	16	15	##	##
April	19	19	15	16	18	16	14	22	16
May	30	25	17	20	19	18	23	21	19
June	24	29	21	21	21	23	25	31	27
July	20	27	18	17	17	18	20	21	24
August	20	23	15	15	16	18	16	20	28
September	36	38	27	24	25	39	27	##	22

TABLE 4.3-3
(Continued)

Month	AQ1	AQ2	AQ3	AQ5C/ AQ5	AQ5D/ AQ5C	AQ9	AQ10	QI1	QI2
SUMMARY									
Pre-Rem		36		33		18			
Phase 1	39	30	30	22	27	22			
Phase 2-1	52	36	30	35	39	27			
Phase 2-2	31	22	19	21	22	17			
Phase 3	24	26	21	21	20	20			
Phase 4	23	25	20	21	20	19	36		
Phase 5-1	#	#	#	#	#	#	#	#	#
Phase 5-2	26	25	18	20	20	20	21	23	23
Summary of 24-Hour Maximum Concentrations**									
PHASE 1									
March		46		34		36			
April		43		39		39			
May		27		19		18			
June		41		19		18			
July		42		35		30			
August		67		39	42	42			
September		61		37	33	41			
October	47	47	46	36	41	35			
November	48	39	34	34	37	32			
December	77	72	60	47	51	51			
PHASE 2 - STAGE 1									
December	51	44	40	43	45	34			
January	95	65	50	71	74	44			
February	168	105	94	116	128	94			
PHASE 2 - STAGE 2									
February	38	23	19	25	27	19			
March	56	33	30	37	41	27			
April	38	29	29	25	26	22			
May	25	19	16	15	15	14			

TABLE 4.3-3
(Continued)

Month	AQ1	AQ2	AQ3	AQ5C/ AQ5	AQ5D/ AQ5C	AQ9	AQ10	QI1	QI2
PHASE 3									
May	34	29	24	26	28	21			
June	33	34	31	28	26	34			
July	35	46	35	33	31	36			
August	20	27	19	19	18	19			
September	39	45	37	29	28	32			
PHASE 4									
October	67	66	56	50	51	43			
November	43	35	35	30	30	29			
December	25	30	20	26	25	17			
January	44	33	23	66	66	22			
February	28	75	59	60	60	57			
March	22	27	15	18	17	16			
April	32	34	25	28	29	25			
May	25	24	20	24	24	29			
June	37	44	33	30	30	37			
July	25	29	24	18	21	26			
August	37	42	34	33	33	30			
September	72	81	72	65	67	71	90		
PHASE 5 - STAGE 1									
October	#	#	#	#	#	#	#	#	#
November	#	#	#	#	#	#	#	#	#
December	#	#	#	#	#	#	#	#	#
January	#	#	#	#	#	#	#	#	#
PHASE 5 - STAGE 2									
January	43	36	20	34	35	20	24	##	##
February	50	32	22	43	45	28	29	##	##
March	33	28	17	27	27	40	28	##	##

**TABLE 4.3-3
(Concluded)**

Month	AQ1	AQ2	AQ3	AQ5C/ AQ5	AQ5D/ AQ5C	AQ9	AQ10	QI1	QI2
April	36	40	30	32	31	28	15	32	31
May	43	40	27	28	27	25	36	34	24
June	30	40	41	30	30	35	37	43	43
July	27	37	28	26	26	27	29	30	35
August	27	37	21	18	21	21	21	30	47
September	70	77	48	40	39	92	48	#	37
SUMMARY									
Pre-Rem		94		90		36			
Phase 1	77	72	60	47	51	51			
Phase 2-1	168	105	94	116	128	94			
Phase 2-2	56	33	30	37	41	27			
Phase 3	39	46	37	33	31	36			
Phase 4	72	81	72	66	67	71	90		
Phase 5-1	#	#	#	#	#	#	#	#	#
Phase 5-2	70	77	48	43	45	92	48	43	47

* Annual arithmetic mean standard is 50 $\mu\text{g}/\text{m}^3$.

** Maximum 24-hour standard is 150 $\mu\text{g}/\text{m}^3$.

Note: Pre-Rem refers to data collected during the Air Remedial Investigation (Environmental Science & Engineering, Inc. 1988).

Phase 1 is from March 22 to December 12, 1988.

Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.

Phase 2, Stage 2 is from February 16 to May 5, 1989.

Phase 3 is from May 6 to September 30, 1989.

Phase 4 is from October 1, 1989 to September 30, 1990 (FY90).

Phase 5 is from October 1, 1990 to September 30, 1991 (FY91).

AQ10 was installed in the northwest quarter of Section 1 on September 5, 1990.

TABLE 4.3-4
COMBINED SEASONAL PM-10 CONCENTRATIONS (in $\mu\text{g}/\text{m}^3$)

	Fall	Winter	Spring	Summer
AVERAGE				
AQ1B	34	36	21	26
AQ2B	33	28	20	31
AQ3B	27	22	15	22
AQ5C	24	28	16	21
AQ5D	26	30	17	21
AQ9B	23	21	16	23
AQ10B	*	23	18	29
QI1B	*	*	21	24
QI2B	*	*	17	26
SEASONAL AVERAGE	28	27	18	25
24-HOUR MAXIMUM				
AQ1B	77	168	43	72
AQ2B	72	105	46	81
AQ3B	60	94	30	72
AQ5C	50	116	39	65
AQ5D	51	128	31	67
AQ9B	51	94	40	92
AQ10B			36	48
QI1B	*	*	34	43
QI2B	*	*	31	47
SEASONAL MAXIMUM	77	168	46	92

* No data available.

TABLE 4.3-5
SEASONAL PM-10 CONCENTRATIONS BY SITE (in $\mu\text{g}/\text{m}^3$)

	Spring	Summer	FY88				FY89				AVERAGE				FY90				FY91			
			Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer
AQ1B	23	33	39	48	25	23	31	21	17	25	*	*	35	22	29							
AQ2B			34	33	20	29	32	23	17	28	*	*	27	20	34							
AQ3B			28	28	18	23	25	17	14	24	*	*	20	14	20							
AQ5C	16	21	25	33	18	21	24	21	16	22	*	*	30	17	20							
AQ5D	22	27	36	19	20	24	21	14	21	*	*	*	30	17	20							
AQ9B	17	22	23	26	15	22	23	17	15	22	*	*	19	17	25							
AQ10B											36	*	*	23	18	22						
Q11B												*	*	*	21	24						
Q12B												*	*	*	17	26						

* No data available.

TABLE 4.3-5
(Concluded)

	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	24-HOUR MAXIMUM	
															FY88	FY89
AQ1B			77	168	38	39	67	44	32	72	*	*	50	43		70
AQ2B	46	67	72	105	29	46	66	75	34	81	*	*	36	40		77
AQ3B			60	94	29	37	56	59	25	72	*	*	22	30		48
AQ5C	39	39	47	116	26	33	50	66	28	65	*	*	43	32		40
AQ5D	42	51	128	28	31	51	66	29	67	*	*	45	31		39	
AQ9B	39	42	51	94	22	36	43	57	29	71	*	*	28	40		92
AQ10B										90	*	*	29	36		48
Q1B											*	*	*	34		43
Q12B											*	*	31	47		

* No data collected for this period

TABLE 4.3-6

**CONCENTRATIONS OF RESPIRABLE PARTICULATES OF LESS THAN
10 MICRONS FOR PHASES 3, 4 AND 5 AT IRA-F SITES (in $\mu\text{g}/\text{m}^3$)**

Month	FC1	FC3
Summary of Arithmetic Mean Concentrations*		
Phase 3 (5/5/89 - 9/30/89)		
June	18	16
July	35	26
August	18	18
September	21	23
Overall	23	22
Phase 4 (10/1/89 - 9/30/90)		
October	38	34
November	22	17
December	15	15
January	16	17
February	15	12
March	14	16
April	21	20
May	13	12
June	24	19
July	23	22
August	32	30
September	49	44
Overall	24	23
Phase 5 (10/1/90 - 9/30/91)		
October	12	6
November	44	28
December	25	19
January	21	20

TABLE 4.3-6
(Continued)

Month	FC1	FC3
February	20	21
March	15	14
April	22	
May	16	
June	28	
July	11	
August	14	
September	21	
Overall	22	19

TABLE 4.3-6
(Continued)

Month	FC1	FC3
Summary of 24-Hour Maximum Concentrations**		
Phase 3 (5/5/89 - 9/30/89)		
June	18	16
July	35	36
August	18	18
September	27	31
Overall	35	36
Phase 4 (10/1/89 - 9/30/90)		
October	54	49
November	31	17
December	15	15
January	23	22
February	17	16
March	20	16
April	27	25
May	14	14
June	32	24
July	27	29
August	39	38
September	102	88
Overall	102	88
Phase 5 (10/1/90 - 9/30/91)		
October	12	6
November	84	36
December	32	23
January	26	25
February	28	29
March	20	18

TABLE 4.3-6
(Concluded)

Month	FC1	FC3
April	35	
May	19	
June	47	
July	19	
August	19	
September	27	
Overall	84	36

* Annual arithmetic mean standard is 50 $\mu\text{g}/\text{m}^3$

** Maximum 24-hour standard is 150 $\mu\text{g}/\text{m}^3$

TABLE 4.3-7

**DENVER METROPOLITAN AREA RESPIRABLE PARTICULATES OF LESS
THAN 10 MICRONS (PM-10)
(in $\mu\text{g}/\text{m}^3$)**

Station	Phase 1	Phase 2-1	Phase 2-2	Phase 3	Phase 4 (FY90)	Phase 5 (FY91)
ARITHMETIC MEANS						
Adams City	40.5	72.8	27.2	31.2	32.1	38.7
8101 Ralston	27.2	36.0	27.2	34.8	**	**
1633 Florence	26.7	31.2	26.3	26.0	24.1	23.1
414 14th Street	30.6	71.7*	39.3*	32.2	31.1	32.9
CAMP/2105 Broadway	28.7	45.1	37.2	27.4	27.3	31.6
1050 S. Broadway	31.2	49.7*	35.2	29.7	32.1	30.8
4857 S. Broadway	23.1	39.9	27.4	23.6	22.0	13.1
24-HOUR MAXIMUM VALUES						
Adams City	103.0	145.0	36.0	50.0	94.0	106.0
8101 Ralston	56.0	57.0	59.0	78.0	**	**
1633 Florence	94.0	77.0	56.0	49.0	84.0	64.0
414 14th Street	66.0	123.0	59.0	54.0	118.0	67.0
CAMP/2105 Broadway	123.0	154.0	62.0	45.0	82.0	95.0
1050 S. Broadway	68.0	64.0	57.0	51.0	118.0	70.0
4857 S. Broadway	48.0	103.0	44.0	39.0	49.0	29.0

* Incomplete data set.

** Samples are no longer collected at this station.

Annual Arithmetic mean standard is 50 $\mu\text{g}/\text{m}^3$.

Maximum 24-hour standard is 150 $\mu\text{g}/\text{m}^3$.

Phase 1 is from March 22 to December 12, 1988.

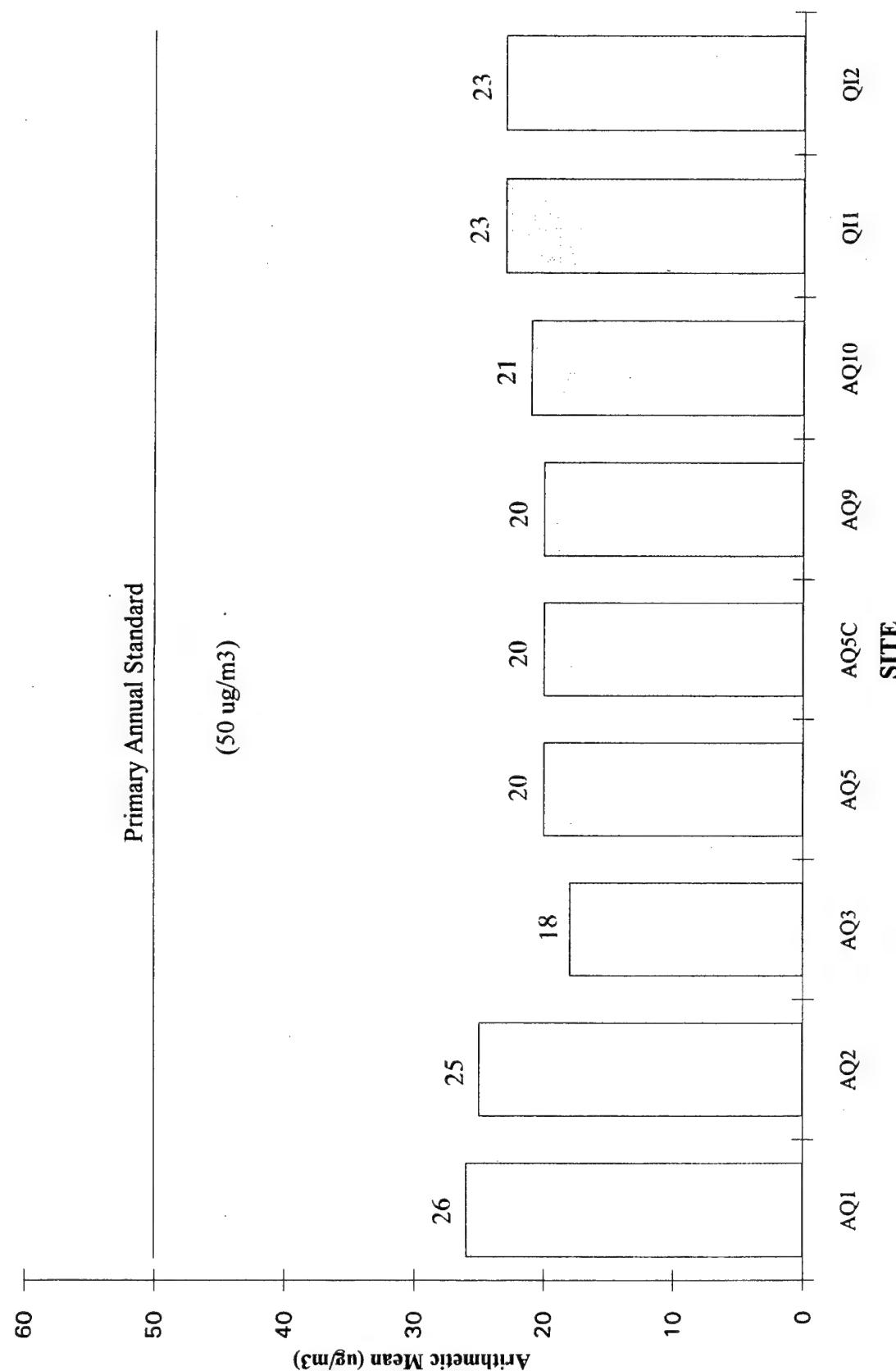
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.

Phase 2, Stage 2 is from February 16 to May 5, 1989.

Phase 3 is from May 6 to September 30, 1989.

Phase 4 is from October 1, 1989 through September 30, 1990.

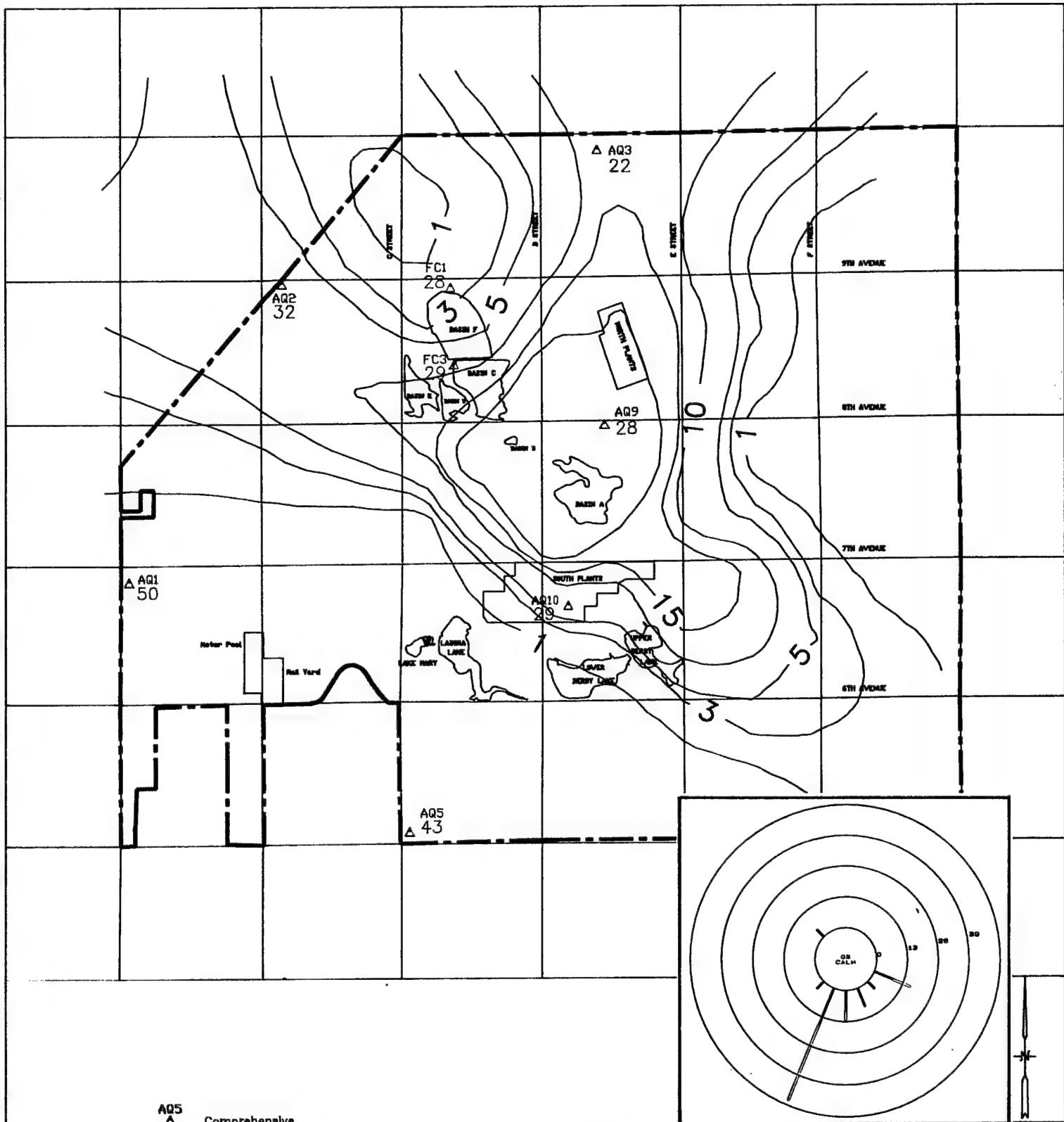
Phase 5 is from October 1, 1990 through September 30, 1991.



Job No. :	22787E
Prepared by :	TRH
Date :	10/22/92

**RESULTS OF RESPIRABLE
PARTICULATES OF LESS THAN
10 MICRONS FOR FY91
AT CMP SITES**





5000 0 5000 10000
SCALE Feet



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

PM-10 Results and x/Q Dispersion for 02/05/91
CMP Air Quality Data Rocky Mountain Arsenal

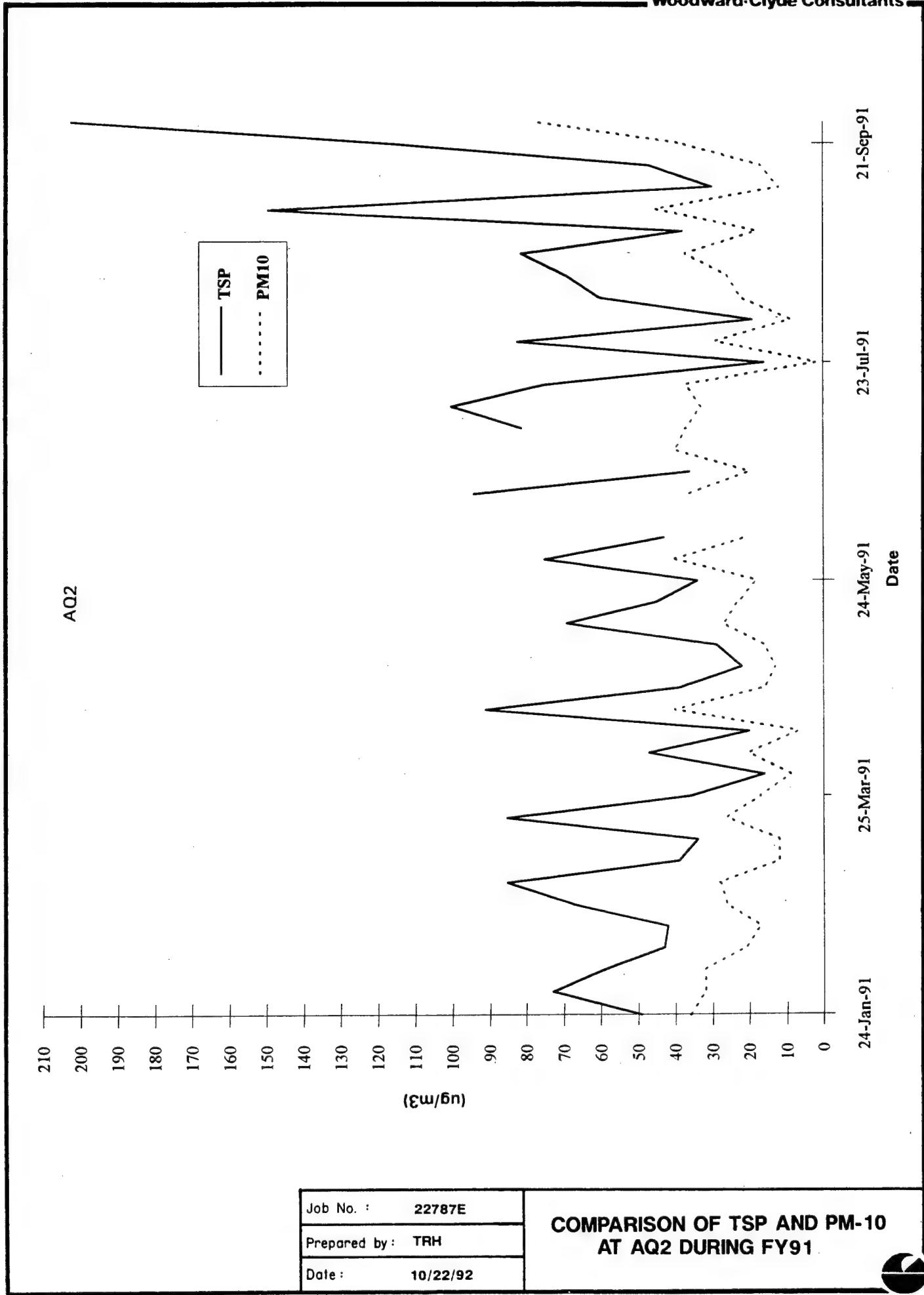
U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb	DATE : 5/5/92
CHKD BY : .	DATE : .

PROJECT NO:
22787E

FIG. NO :
4.3-2



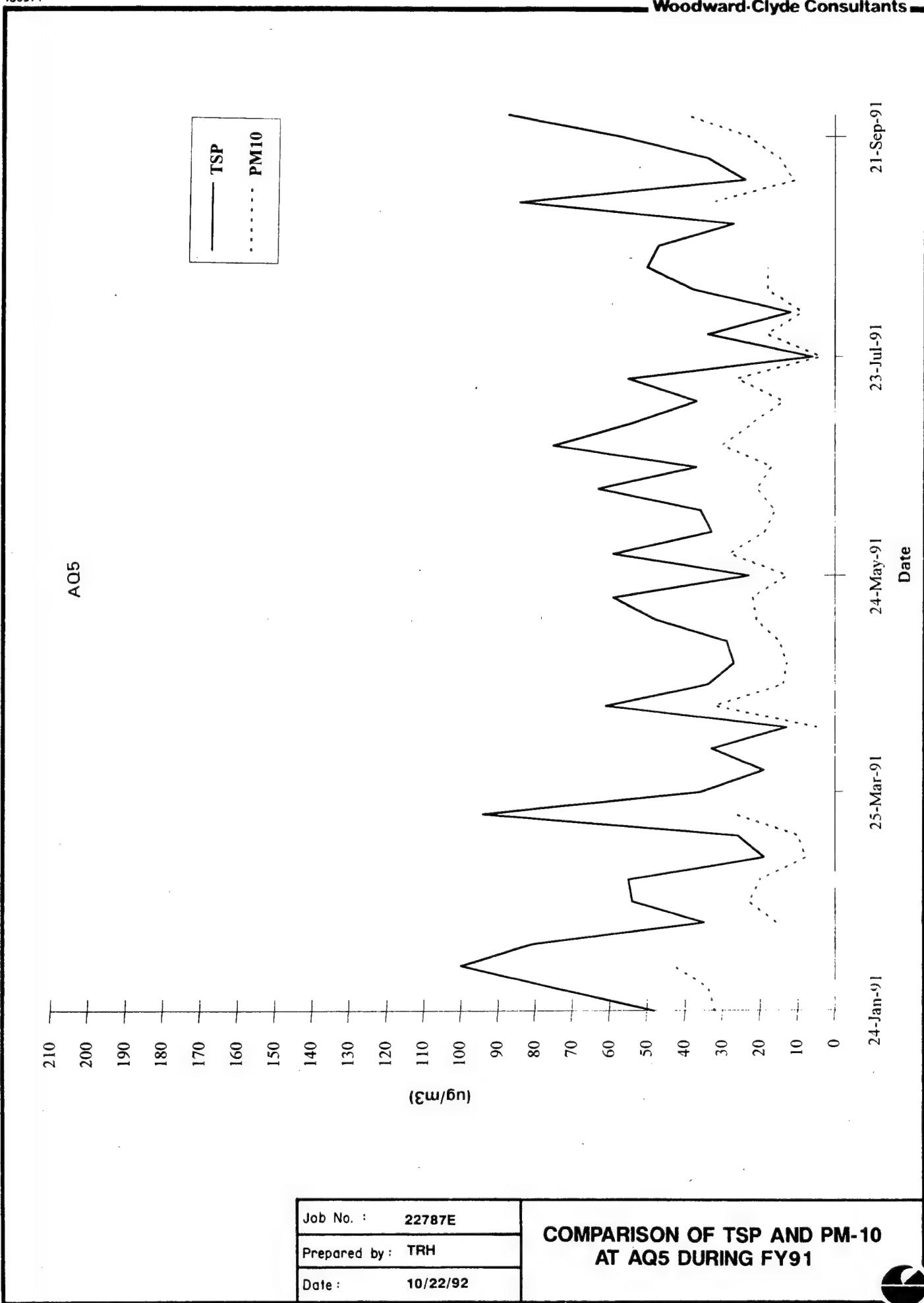
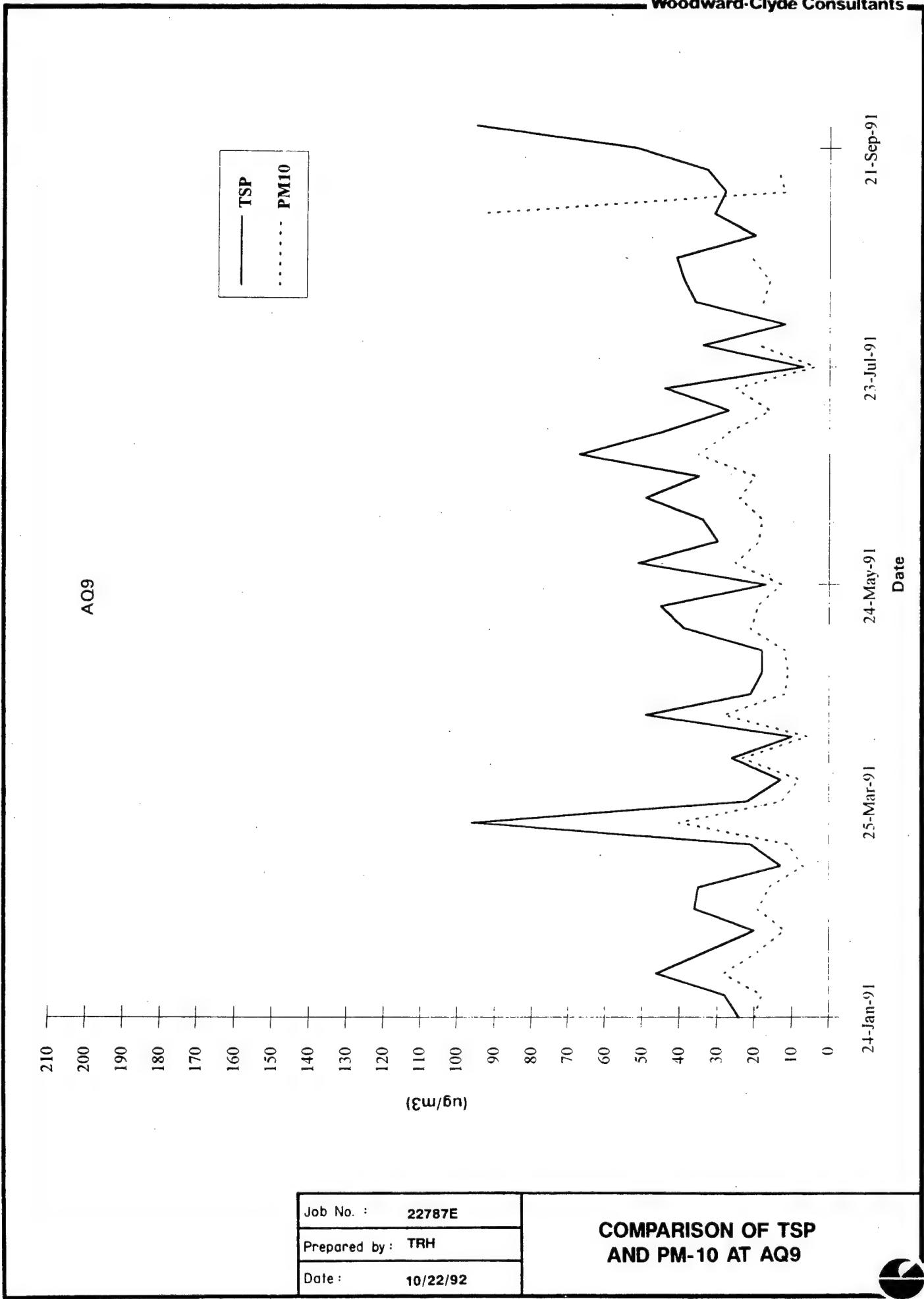
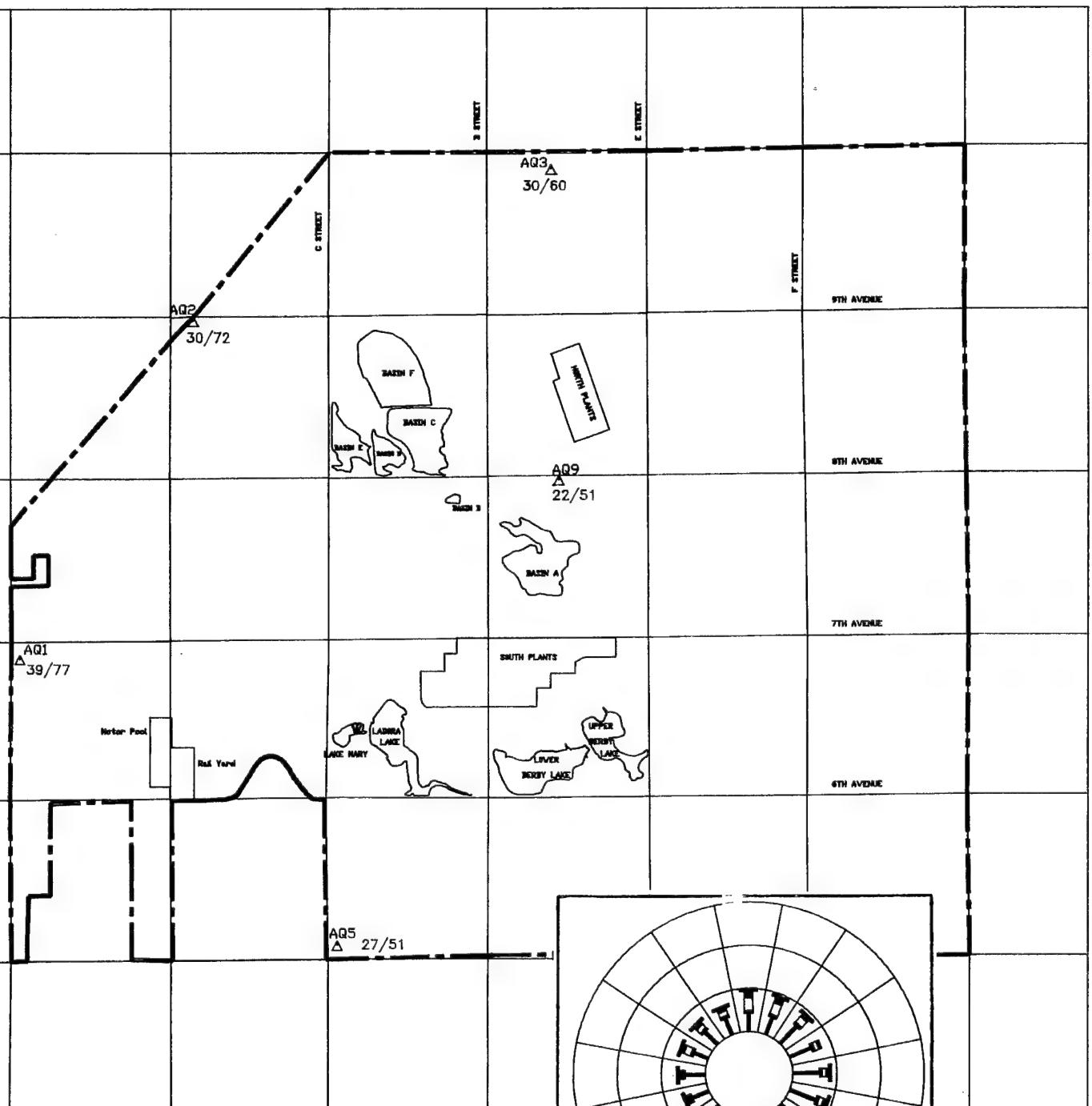


FIGURE 4.3-4





LEGEND

AQ5 Comprehensive Monitoring Location

△ Arithmetic mean / 24 Hour Maximum ($\mu\text{g}/\text{m}^3$)

5000 0 5000 10000
SCALE Feet



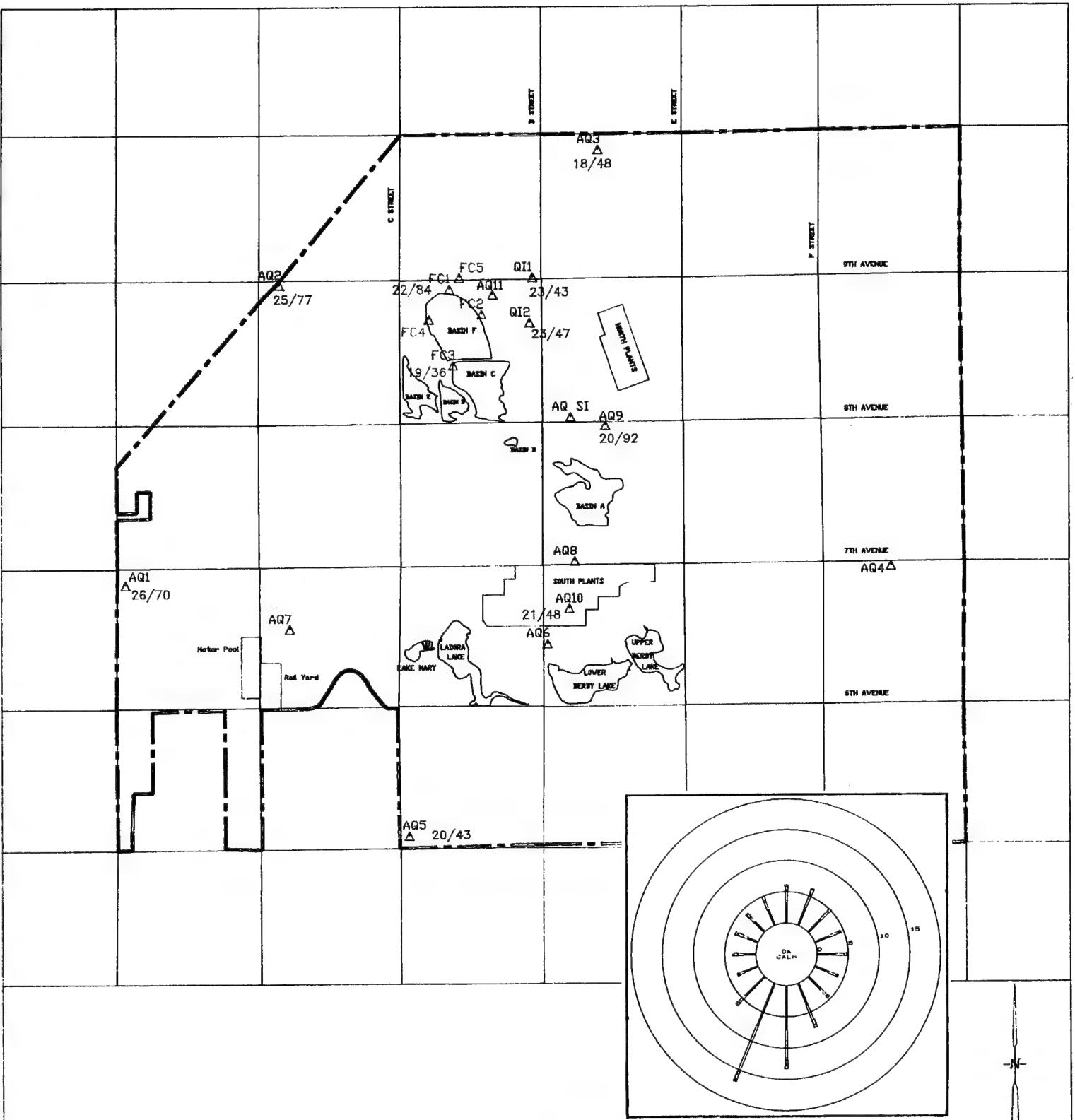
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

Composite PM-10 Analysis for Phase 1
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb	DATE : 5/5/92	PROJECT NO: 22787E	FIG. NO : 4.3-6
CHKD BY :	DATE :		



LEGEND

Comprehensive Monitoring Location

CMP FC Sites (Formerly IRA-F)

Arithmetic mean / 24 Hour Maximum ($\mu\text{g}/\text{m}^3$)

5000 0 5000 10000
SCALE Feet



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

Composite PM-10 Analysis for Phase 5
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb DATE : 5/5/92

PROJECT NO: 22787E FIG. NO :

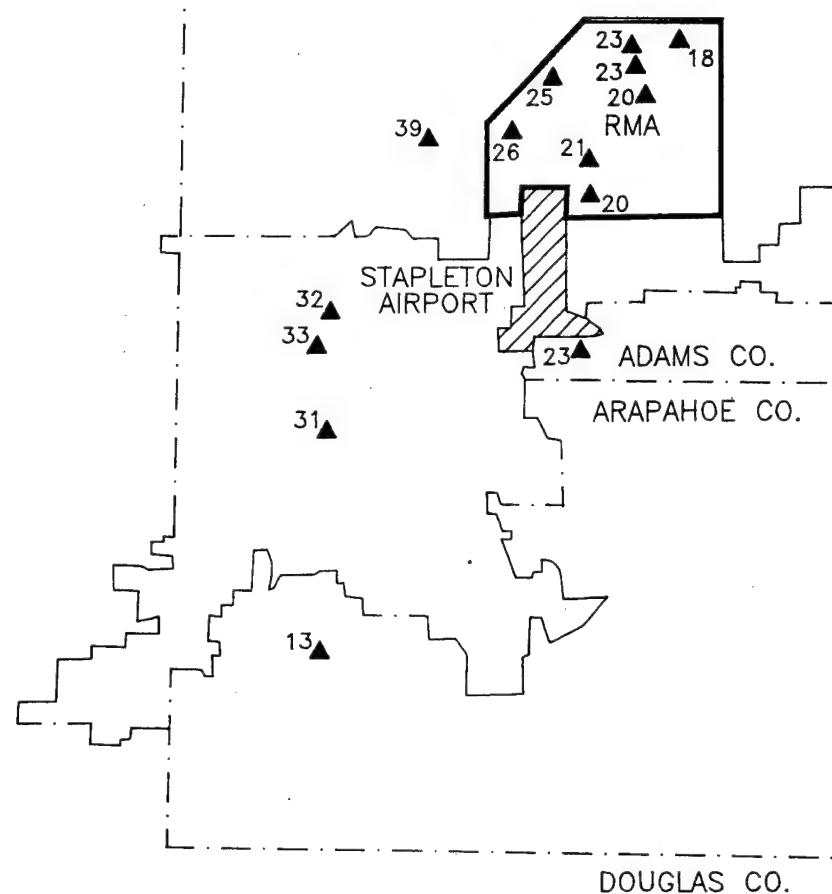
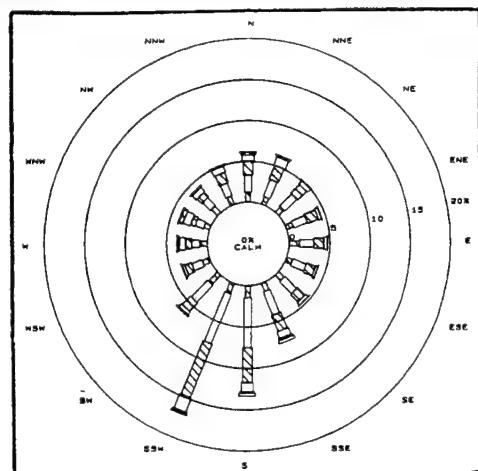
CHKD BY : DATE :

4.3-7

BOULDER CO.

JEFFERSON CO.

WELD CO.



DOUGLAS CO.



0 2.5 5

 SCALE IN MILES

Job No. :	22787E
Prepared by :	T.R.H.
Date :	10/23/92

Denver Area PM-10 Data for
Phase 5 Arithmetic Means
($\mu\text{g}/\text{m}^3$)

4.4 METALS

A total of six metallic ions were analyzed from the TSP filters after the filters were weighed, including arsenic, cadmium, chromium, copper, lead and zinc. Mercury was measured using Hydrar tubes and analyzed using the Rathje and Marcero method (Rathje and Marcero, May 1976).

4.4.1 Metals Monitoring Strategies

There were basically two components of the CMP FY91 metals monitoring effort. The first component was routine monitoring which involved every 6th day sampling at four sites, AQ3, AQ5, QI1, and QI2. A summary of data recovery for routine metals sampling for both the CMP and the former IRA-F sites are presented in Table 4.4-1.

The second component involved "high event" monitoring during specified high wind episodes (i.e., as a minimum, winds in excess of 10 mph). Six high event episodes were conducted for the six metal ion components and also for mercury. Monitoring was conducted at various locations across the Arsenal depending upon meteorological conditions and selected source activities of special interest.

The CMP FY91 high event metals program included both direct mobilization episodes around Basin F, Basin A, the South Plants, Basin A Neck, and the South Plants subdrain area, and post-analysis episodes at strategically located monitoring sites across the Arsenal. In most cases, winds were in excess of 10 mph, and gusts were frequently in excess of 25 mph, thus meeting the wind speed criteria established for high event analysis. In several cases, however, post-analysis of high TSP levels provided the criteria for high event metals analyses. This approach provided a practical and cost effective method of obtaining data for days with potentially high metals concentrations. Metals analyses were obtained from TSP sample filters that were strategically located at interior and perimeter Arsenal sites.

4.4.2 CMP FY91 Metals Monitoring Results

Average and maximum concentrations for the full CMP metals monitoring program for arsenic, cadmium, chromium, copper, lead and zinc are shown in Table 4.4-2, with detailed data in Appendix C. Metals data summaries for stations AQ3, AQ5 and AQ5C are comprised of data collected every six days from January 24 to September 27, 1991. QI1 and QI2 metals data are based on samples collected every six days from April 6, 1991 to September 27, 1991. All other CMP monitoring stations data including mobile sites comprise results of high event monitoring periods, which were 24-hour periods except for a 8-hour sampling event at four mobile sites on July 11, 1991.

Results of the CMP FY91 metals monitoring program were generally comparable to past CMP results. Metals levels detected were very low to insignificant with respect to ambient standards and health criteria (to be discussed in Section 4.4.5). With several exceptions, metals levels were fairly consistent across the Arsenal and for the most part were representative of their proximity to the Denver urban environment. For example, the highest average concentrations for a majority of the metals occurred at AQ2 and AQ5 on the northwestern and southern Arsenal boundaries. The highest average concentrations for cadmium and arsenic occurred at QI1 and AQ12, respectively, located near Basin F. Maximum 24-hour concentrations of several metals occurred at sites downwind of Basin F when strong winds in conjunction with post-remedial restoration activities were present. These maximum 24-hour concentrations were still well below Phases 1 and 2 concentrations measured during Basin F remedial activities. Maximum average and 24-hour concentrations measured in FY91 for each metal component are discussed below.

The maximum average cadmium value was $0.0013 \mu\text{g}/\text{m}^3$ measured at QI1 and the maximum 24-hour value was $0.0032 \mu\text{g}/\text{m}^3$ also measured at QI1.

During FY91, the maximum average value of chromium was $0.0114 \mu\text{g}/\text{m}^3$ at AQ2, while the maximum 24-hour value of $0.0238 \mu\text{g}/\text{m}^3$ was measured at AQ1. In FY88, chromium was detected only at AQ3, was detected at Stations AQ7 and AQ12 during FY89, and only at AQ5 during FY90. No specific pattern of chromium concentrations at Arsenal sites appears to be evident.

The highest average copper level, $0.1616 \mu\text{g}/\text{m}^3$ occurred at AQ5C, the collocated sampler on the southern RMA boundary; the maximum 24-hour value of $0.3120 \mu\text{g}/\text{m}^3$ was also measured at AQ5C. Copper concentrations at AQ5 was only slightly less than these values but significantly less at the other RMA sites. The highest CMP copper concentrations during FY88, FY89, and FY90 were measured at AQ3.

The highest average lead concentration was $0.0144 \mu\text{g}/\text{m}^3$ at AQ5C at the southern perimeter of the Arsenal. The 24-hour maximum lead value was $0.0536 \mu\text{g}/\text{m}^3$ at QI1 near the quench incinerator construction site. QI1 had an average copper concentration of $0.0136 \mu\text{g}/\text{m}^3$, nearly the same as at AQ5C. These values were consistent with previous CMP measurements. During FY88, the highest measured average lead concentration was $0.0270 \mu\text{g}/\text{m}^3$ and the maximum 24-hour concentration was $0.0576 \mu\text{g}/\text{m}^3$, both at AQ2 along the northwestern perimeter. The highest average lead value measured during FY89 was $0.0291 \mu\text{g}/\text{m}^3$ while the highest 24-hour value was $0.0994 \mu\text{g}/\text{m}^3$ at AQ5. During FY90, the highest average and 24-hour concentrations also occurred at AQ5 with values of 0.0331 and $0.0621 \mu\text{g}/\text{m}^3$, respectively.

A maximum average zinc concentration of $0.0364 \mu\text{g}/\text{m}^3$ was measured at AQ7. A maximum 24-hour concentration of $0.0810 \mu\text{g}/\text{m}^3$ was measured at QI2. During FY89, the highest zinc levels were measured at AQ1 and AQ2 at the western boundary. During FY89, zinc levels at these stations were next highest after AQ7, where one isolated 24-hour measurement of $0.2908 \mu\text{g}/\text{m}^3$ was recorded. The maximum average zinc concentration during FY90 was $0.0371 \mu\text{g}/\text{m}^3$ at AQ7 and the highest 24-hour concentration was $0.1086 \mu\text{g}/\text{m}^3$ at AQ5.

The maximum average arsenic level was $0.0027 \mu\text{g}/\text{m}^3$ and the maximum 24-hour concentration has $0.0050 \mu\text{g}/\text{m}^3$, both measured at AQ12, near the North Plant. The maximum 24-hour arsenic concentration of $0.0050 \mu\text{g}/\text{m}^3$ occurred on a day when winds were consistently above 17 mph with gusts to 45 mph. TSP concentrations on this day were also elevated with a maximum 24-hour concentration of $247 \mu\text{g}/\text{m}^3$ at AQ11. During FY88 and FY89, AQ8 which is close to Basin A measured the highest arsenic levels under the CMP. During FY90, the maximum average and 24-hour arsenic concentrations occurred at a mobile site near Basin A.

Mercury was not detected throughout the CMP FY91 Monitoring Program. The lower certified reporting limit for mercury is $0.231 \mu\text{g}/\text{m}^3$. Mercury sampling was conducted during 12 separate high event episodes for a total of 95 samples (includes former IRA-F sites and Basin F sites). These samples were collected throughout the year and focused on a variety of sources which might have acted as potential sources of mercury emissions.

During FY91, high event monitoring was conducted in vicinity of Basin F, the quench incinerator construction area, the North Plants, and the South Plants subdrain area as summarized in Table 4.4-3. Samples from the mobile site (Mobile E) surrounding the quench incinerator construction area on July 2, 1991 were designated as AQ25, indicative of the section location of the site. Samples from the mobile sites surrounding the North Plant on July 11, 1991 were designated as AQ35 (Mobile W) or AQ36 (Mobile E and EC), in reference to section location. Samples from the three mobile sites (Mobile E, Mobile EC, and Mobile W) surrounding the South Plants subdrain area on July 17, 1991 were designated as either AQ01 or AQ02, indicative of the section location of the sites. Three of the six high event scenarios are examined individually as representative of the varying distribution and magnitude of metals concentrations as a result of meteorological dispersion conditions and the characteristics of the primary emission source potentially contributing to observed metals concentrations. These three high events are presented in the following sections.

4.4.2.1 March 19, 1991

As presented in Figure 4.4-1, high event metals monitoring on this date encompassed a broad distribution of site locations across the Arsenal, including 12 fixed CMP stations and four Basin F (IRA-F) sites. Monitoring occurred during the period from 0100 to 2400 on March 19. The average wind speed was 17.4 mph from the south and south-southeast with peak gusts in excess of 45 mph from the south-southeast. Strong, gusty winds also occurred from the west-northwest (see wind rose insert on Figure 4.4-1). Meteorological conditions on this day were conducive to high metals concentration contributions from local ground-level sources. TSP concentrations at the Arsenal were two to three times greater than typical levels and several metals constituent concentrations were also elevated. The highest copper concentration measured was $0.2763 \mu\text{g}/\text{m}^3$ at FC2 north of Basin F; the highest zinc level was $0.0681 \mu\text{g}/\text{m}^3$, also at

FC2; the highest arsenic levels measured were $0.0050 \mu\text{g}/\text{m}^3$ at AQ12 and $0.0042 \mu\text{g}/\text{m}^3$ at AQ11. These concentrations were above average for the FY91 monitoring period but still well below previous peak levels measured during the composite CMP. Several metals concentrations including cadmium, chromium, lead, and mercury were either below the certified reporting limit or were very low despite the windy conditions. The area around Basin F, as indicated by metals concentrations at FC2, appeared to be a source of several metals. However, Basin A, a previous sensitive area, did not contribute high metals concentrations as indicated by metals concentrations at the upwind and downwind stations AQ8 and AQ9.

4.4.2.2 March 25, 1991

High event metals monitoring on this date focused on four Basin F sites (FC1, FC2, FC3, and FC4) and four perimeter sites (AQ1, AQ3, AQ4 and AQ5) (Figure 4.4-2). Monitoring was conducted from 0100 to 2400 on March 25. The average wind was 10 mph on this date; however, peak gusts reached 35 mph. Winds were primarily from the southwest as shown in the wind rose insert. Only copper and zinc concentrations were measured above the certified reporting limit on this date. The maximum copper level, $0.5288 \mu\text{g}/\text{m}^3$, measured downwind from the strong winds at Basin F site FC-2 was the highest copper measurement during FY91E. The maximum zinc concentration was measured at AQ1 on the western Arsenal perimeter.

4.4.2.3 July 2, 1991

On this high event scenario day, the metals concentrations that were monitored focused on the area surrounding the quench incinerator construction site to evaluate the metals impact of ground disturbance activity in this area (Figure 4.4-3). Four sites surrounding the area (QI1, QI2, FC2, and Mobile E) were sampled and metals monitoring was also conducted at four RMA perimeter sites (AQ1, AQ3, AQ4, and AQ5). This was a typical summer day. Winds were variable averaging 8 mph; however, gusts occasionally reached 20 mph. Most metals concentrations measured were at low levels or below certified reporting levels. The highest chromium concentration, $0.0549 \mu\text{g}/\text{m}^3$, was measured at FC2, west of the incinerator construction site; the only other chromium concentrations recorded were at AQ1 at the western Arsenal perimeter and AQ3 at the northern

perimeter. The highest copper level, $0.1467 \mu\text{g}/\text{m}^3$, and zinc level, $0.0371 \mu\text{g}/\text{m}^3$, were measured at AQ1 at the western Arsenal boundary. Elevated copper and zinc concentrations were also measured at the four stations surrounding the incinerator construction site.

4.4.3 Assessment of Basin F Metals Impacts

4.4.3.1 CMP Data

In order to fully evaluate remedial impacts from the Basin F cleanup operations, it is necessary to consider all CMP, Basin F Remedial Monitoring Program, and IRA-F data for the entire remedial and post-remedial periods. CMP FY91 metals results were discussed in the previous section. Table 4.4-4 incorporates CMP FY88, FY89, FY90, and FY91 data and stratifies results for each monitoring station for the Phase 1 and Phase 2 remediation periods and the Phases 3, 4, and 5 post-remedial periods. These data reflected no significant metals impacts from Basin F at CMP monitoring sites over the 43-month monitoring period. For each metal element analyzed, variations (at fixed and mobile monitoring stations) were small and likely reflected individual wind and TSP conditions as well as some seasonal differences. Basin F program monitoring sites immediately adjacent to the intense remedial activity measured higher concentrations of several metal elements (chromium, copper, zinc, and mercury) during the Basin F cleanup operations. These concentrations decreased during the post-remedial periods. The lack of a significant remediation and post-remediation metals concentration distribution at CMP sites, not immediately downwind from the Basin F monitoring sites, substantiates the premise that Basin F metals impacts were highly localized and decreased rapidly with distance from the remedial activities. The CMP metals concentrations measured during the remediation phases (Phase 1 and Phase 2, Stage 1) that encompassed the Basin F remediation activity were comparable to high event metals data collected under the 1986-1987 Remedial Investigation Program shown in Table 4.4-5.

4.4.3.2 Basin F Data

Table 4.4-6 shows average and maximum metals values for the Basin F Remedial Monitoring Program and for the IRA-F Monitoring Program for Phases 1 through 5 of the remediation activities and postremediation periods. All Phase 1 data and Phase 2 (Stage 1 and Stage 2) data were obtained from the Basin F Remedial Monitoring Program and cover the period from March 22, 1988, through May 5, 1989. The Phase 3 Phase 4, and Phase 5 data were obtained from the IRA-F Monitoring Program, and the integrated program covering a period from May 6, 1989, through September 30, 1991. Sequential data for the IRA-F program are provided in Appendix C.

Figures 4.4-4 through 4.4-10 graphically depict maximum and average concentrations for each metal component. The data are also stratified by the remedial phase periods. The metals summaries and corresponding figures show that several metals components, chromium, zinc and mercury, appeared to be impacted by Basin F remedial operations, especially at the sites immediately around the Basin F perimeter. Chromium exhibited highest measured concentrations during the Phase 1 remedial operations at the four monitoring sites immediately surrounding the Basin F perimeter (Figure 4.4-4). The maximum average value was $0.0200 \mu\text{g}/\text{m}^3$ at BF4 and the maximum 24-hour value was $0.2858 \mu\text{g}/\text{m}^3$, also at BF4; these values decreased substantially at the more distant Basin F monitoring sites (BF5, BF6 and BF7), and were comparable to maximum values at CMP monitoring sites.

During the Phase 2 period, chromium levels immediately surrounding Basin F decreased by factors of 3 to 7 and were comparable to levels at the more distant Basin F and CMP monitoring sites. Chromium was not detected at any of the sites during Phase 3, and was detected at minimal levels at FC1, FC2, and FC5 during Phase 4 and Phase 5.

Some chromium impacts appeared to occur in the immediate vicinity of Basin F during the early stages of the remediation program. These impacts were highly localized and decreased to typical background levels at the conclusion of the remediation activities. However, elevated levels of chromium at FC1, FC2 and FC5 only, similar to Phase 1 levels at these sites, were measured during Phase 5 due to reasons not readily apparent. The health impacts of the higher chromium levels during remediation and Phase 5, and

from other metals during remedial and post-remedial phases, will be discussed in Section 4.4.5.

A similar pattern was shown for copper levels in the vicinity of Basin F (Figure 4.4-5) although copper concentrations did not approach Phase 1 levels during Phase 5. Moderately higher copper concentrations were measured at the Basin F perimeter sites during Phase 1 and decreased with distance. The maximum average value was $0.1539 \mu\text{g}/\text{m}^3$ at BF2C and the maximum 24-hour value was $1.4980 \mu\text{g}/\text{m}^3$ at BF2. During Phase 2 maximum copper levels at the Basin F perimeter decreased to values comparable to the more distant Basin F monitoring sites and the CMP monitoring sites. However, during the Phase 3 monitoring period mean copper concentrations again increased to the highest levels measured during the 43-month monitoring period. One possible explanation is that this was a seasonal phenomenon, as almost all CMP monitoring sites across the Arsenal also showed increased copper levels during the Phase 3 period. Copper levels continued to decrease during Phase 4 with a slight increase evident at FC1, FC2 and FC3 during Phase 5. Nevertheless, several high maximum 24-hour copper concentrations measured near the perimeter of Basin F during the Phase 1 remediation period indicate that Basin F may have been a source of copper emissions during more intensive cleanup activities.

Measured mercury concentrations during the Phase 1 monitoring period were roughly equivalent at all seven sites (Figure 4.4-6). A maximum 24-hour value of $7.3 \mu\text{g}/\text{m}^3$ occurred during Phase 1 at BF2 and BF3. Some very sporadic, localized mercury impacts were noted during Phase 2 (Stage 1), with minimal to no impact recorded during Phase 2 (Stage 2), and Phase 3. However, mercury was again detected at all Basin F sites at low levels during Phase 4. This trend was not continued during Phase 5 as all measured mercury concentrations were below detection limits.

Zinc concentrations followed an atypical pattern with the highest levels recorded at Basin F during the Phase 2 (Stage 1) dirt moving and landscaping period, rather than the Phase 1 remediation period (Figure 4.4-7). This trend could have been a function of the soil that was moved during the covering period; however, this could also have been a function of an analytic problem in that subsequent quality assurance review identified high zinc (and arsenic) levels in some TSP filters prior to sampling. The

maximum average zinc level recorded in Phase 2 was $0.3260 \mu\text{g}/\text{m}^3$ at BF5; the maximum 24-hour level was $3.3576 \mu\text{g}/\text{m}^3$ at BF5. During Phases 3, 4 and 5, zinc concentrations at Basin F were comparable to other CMP concentrations across the Arsenal.

Arsenic and lead concentrations reflected minimal changes during Phases 1 through 5 and were comparable to other measurements at the CMP monitoring sites (Figures 4.4-8 and 4.4-9). A one time 24-hour maximum arsenic level of $0.0136 \mu\text{g}/\text{m}^3$ was measured at BF5 during Phase 1; all other 24-hour maximum values were equivalent to CMP levels. The maximum 24-hour Basin F lead value during Phase 1, $0.0614 \mu\text{g}/\text{m}^3$ at BF2, was less than the maximum CMP 24-hour value of $0.0984 \mu\text{g}/\text{m}^3$, measured at AQ5 during Phase 2, Stage 1 and less than the value of $0.108 \mu\text{g}/\text{m}^3$ measured at RIFS1 (at the northeast boundary of the Arsenal) during Phase 2, Stage 1. Basin F does not appear to be a source of these two metals.

Cadmium concentrations indicated small differences at all Basin F stations during the Phase 1 and Phase 2 periods (Figure 4.4-10). During Phase 3, cadmium concentrations were actually slightly higher than during the earlier Basin F remediation periods, but overall cadmium levels were very low; the highest average concentration was $0.0027 \mu\text{g}/\text{m}^3$ measured at BF2. No obvious explanation is apparent for the elevated cadmium levels in the vicinity of Basin F during the Phase 3, post-remedial phase. Cadmium values were generally lower during the Phase 4 and Phase 5 periods, except for an unexplained spike at FC3 during Phase 5. The highest 24-hour cadmium concentration, $0.0253 \mu\text{g}/\text{m}^3$, was measured at CMP Station AQ5 at the extreme southern end of the Arsenal. As will be discussed in Section 4.4.5, all cadmium concentrations were well below general toxic guidelines.

Ammonia was monitored every day during the Basin F program at three sites (BF5, BF6 and BF7) but only 1 day per week was analyzed which corresponded to observed conditions that would result in greatest impacts from Basin F activities. Monitoring was conducted only during Phases 1 and 2. Detectable concentrations were sampled only during Phase 1 with a maximum reading of $822 \mu\text{g}/\text{m}^3$ at BF5 and a highest average reading of $284 \mu\text{g}/\text{m}^3$, also at BF5. No ammonia sampling was conducted in Phase 3, Phase 4, or Phase 5.

Another approach to assessing remedial progress is to consider Basin F impacts that were observed on individual days during the remedial and post-remedial periods. All Basin F air monitoring during the Phase 1 period was conducted for worst-case, 24-hour periods based on dispersion model analysis and remedial activity. An example of the dispersion of metals resulting from Basin F remedial activities (Phase 1) is shown in Figure 4.4-11. This figure shows metals concentrations for September 6, 1988, with X/Q dispersion values overlaying the monitoring data for seven Basin F stations. This analysis identifies the potential dispersion pattern of metals and other contaminants that would result from remedial actions being the primary emissions source. On this day, winds were from the south-southwest at moderate speeds. Peak levels for most metals occurred at the closest downwind sites. Sites further downwind and upwind from Basin F measured lesser values, substantiating the dispersion pattern that would result from Basin F being the primary metals source. An example of a typical post-remedial sampling day is June 10, 1990, during Phase 4 (FY90). The X/Q dispersion pattern and the reported concentrations for this day are shown in Figure 4.4-12. The dispersion pattern and meteorological conditions are similar to the Phase 1 day. However, a decrease in concentrations is evident for several metals and does not clearly show Basin F as the primary source contributor to observed impacts. These data further support the conclusion that Basin F impacts occurred during Phase 1, but were significantly reduced by Phase 4, a typical post-remedial period.

4.4.3.3 Combined CMP and Basin F Data Analyses

Individual CMP and Basin F metals monitoring data for the remedial and post-remedial phases of the monitoring programs have been shown in Tables 4.4-4 and 4.4-6. Figures 4.4-13 and 4.4-13A provide a depiction of all available average and 24-hour maximum metals data across the Arsenal complex during the Phase 1 remediation phase. Figures 4.4-14 and 4.4-14A provide the same information for the most recent Phase 5 post-remedial period. All maximum periods are 24 hours except for monitoring on July 11, 1991, when sampling was conducted for approximately 8 hours at the mobile sites designated as AQ35 and AQ36. Corresponding annual wind roses for Phases 1 and 5 are also shown in these figures. These data confirm individual results previously discussed in addition to showing the influences of meteorology and atmospheric dispersion impacts, distance from a potential source, and which source(s) were of

primary influence. For example, Figures 4.4-13 and 4-4.4-13A show average and maximum concentrations during Phase 1 for CMP sites and seven Basin F sites, and indicate the highest levels of chromium, copper, lead and zinc adjacent to Basin F and immediately downwind from the source, indicated by the prevailing wind flow. Station BF2, which was located in the northeast corner of the Basin immediately downwind from the prevailing flow and which was the closest station to much of the remedial activity, measured highest concentrations for most metals. There were several exceptions such as highest chromium levels being measured at BF4. In general, except for cadmium and lead, metals values decreased with distance from the Basin F source. Several metals compounds (i.e., cadmium, lead, and arsenic) measured highest concentrations along the RMA boundaries during the Phase 1 period, suggesting that there were neither Basin F nor Arsenal sources.

Figures 4.4-14 and 4.4-14A show the distribution of average and maximum metals concentrations at Basin F and across RMA during the Phase 5 post-remedial period. All metals levels were typical of background regional levels. Dispersion conditions were similar to the previous remedial phase periods, inferring that any metals components that were indigenous to the Basin F compound were evident only during the remediation process, although as previously noted, cadmium was slightly higher in the vicinity of Basin F during the Phase 3 period and chromium exhibited elevated concentrations at FC1, FC2 and FC5 during Phase 5.

4.4.4 Analysis of Metals Source Factors

Detectable concentrations of metals monitored in the RMA vicinity appeared to result from a variety of sources. Observed concentrations of several metal elements may have originated from metals deposited in the soil around Basin F; other concentrations may have resulted from industrial and transportation activities in the Denver metropolitan area. Inherent in all the observed metals concentrations are baseline levels typical of the area's semi-urban environment. With the exception of transportation and industry related components, the metals were probably transported primarily by wind-blown dust and soil particles. In a CMP study conducted in FY89 (RLSA, 1990), the relationship was assessed between total metals (the sum of concentrations of all targets) collected under the Basin F program and TSP levels at Basin F during all remediation phases for

Site BF2. Although there were typical variations in this database (the overall correlation factor was 0.68), the general inference was that the higher the TSP levels, the higher the levels of metals collected in the sample filters.

An analysis of average and maximum metals concentrations for FY91 indicated that, as in past years, high metals concentrations at RMA monitoring sites resulted from a number of sources and occurred under meteorological conditions conducive to high pollutant concentrations. In the CMP FY88 Data Assessment Report, Table 4.2-16 showed in almost every case that the highest metal concentrations for each element at each monitoring site were associated with average 24-hour winds in excess of 10 mph and wind gusts in excess of 25 mph (RLSA, 1990). In contrast, the majority of high metals episodes during FY89 resulted from "brown cloud" inversion impacts from metropolitan Denver, as shown in Table 4.4-6 of the FY89 Data Assessment Report (RLSA, 1990). In fact, two-thirds of the cases with the highest metals levels occurred during three winter "brown cloud" episodes (January 4, February 9, and March 11, 1989). Very high TSP and PM-10 concentrations at all RMA monitoring sites were also recorded on these dates, even though wind speeds were not very strong or gusty. Prevailing winds in all cases were from the south or southwest, indicating that impacts were from metropolitan Denver.

Table 4.4-7 is an update of maximum 24-hour metals concentrations including the FY91 metals data and encompassing the entire 4 years of CMP monitoring. The majority of high concentrations for all elements still occurred during FY88 and FY89; however, there were two elements with maximum concentrations measured in FY91. The highest chromium concentration for the 4-year period was $0.055 \mu\text{g}/\text{m}^3$ measured at FC2 at the northeast corner of Basin F on July 2, 1991. Wind speeds on this day averaged 8 mph with gusts up to 20 mph, mainly from the east-northeast and west-southwest. The highest copper concentration, $0.529 \mu\text{g}/\text{m}^3$, was also measured at FC2 on March 25, 1991. Wind speeds averaged 10 mph and were from the southwest with peak gusts of nearly 35 mph.

The distribution of the metals concentrations indicate that strong, gusty winds remained a principal criteria for high metals levels at RMA during FY91, particularly downwind of the restored Basin F cap when intermittent post-remedial activities occurred.

During the Basin F remediation period, higher levels of chromium, copper, zinc and mercury were identified in the immediate vicinity of the disturbed area. During the post-remedial period, however, Basin F monitoring stations reported significantly reduced metals concentrations that were comparable to the CMP interior sites, except during intermittent post-remedial activities. During these events, some metal components currently indigenous to the Arsenal soil appeared to impact sites in vicinity of Basin F.

While higher metals continued to be a function of strong and gusty winds, especially downwind from local construction and remediation activities, metals concentrations were generally higher during fall and winter inversion periods than under high wind scenarios. Table 4.4-8 shows average and 24-hour maximum seasonal metals concentrations for the 4-year monitoring period. Stations AQ3 and AQ5 have monitored metals concentrations every 6th day since the start of the CMP and were selected for presentation in Table 4.4-8 to provide a complete basis of comparison. The highest lead, zinc and arsenic levels for both the average and 24-hour maximum values occurred in the fall or winter seasons. During spring when winds were frequently the strongest, lower concentrations were experienced for most metals except chromium, which was detected primarily during the spring and summer. In contrast, copper concentrations were reported at their highest during summer.

Table 4.4-9 below summarizes the locations of maximum metals concentrations from both the CMP and Basin F monitoring programs throughout the 43-month period. Comparisons of maximum short-term (24-hour) and long-term metals concentration to toxic guidelines are discussed in the next section.

4.4.5 Assessment of Metals Concentrations Relative to Toxic Guidelines

In order to assess the significance of the measured metals concentrations relative to health standards and available toxic guidelines, a literature search was performed to compile applicable standards and guidelines. This search was performed because the EPA and the State of Colorado have promulgated standards and published air toxic guidelines only for lead. Promulgated state air toxics standards are not anticipated until amendments to Section 112 of the Clean Air Act are finalized in 1996. Sources of

information that were reviewed included the ACGIH TLV Handbook, the NIOSH Pocket Guide to Chemical Hazards, and the NATICH Database Report on State, Local, and EPA Air Toxic Activities (ACGIH, 1991; NIOSH, 1990; U.S. Environmental Protection Agency, 1991).

The tabulation of guideline concentrations is presented in Table 4.4-10. For each target metal, the name and Chemical Abstract number is presented, along with the Threshold Limit Value (TLV) and TLV/420 concentrations, expressed as $\mu\text{g}/\text{m}^3$. The reason for presenting the TLV/420 is that this value is used by many states in air toxic regulations as an annual concentration guideline not to be exceeded. The next three columns of information are risk-based air concentrations (RBACs) derived from the Integrated Risk Information System (IRIS; USEPA on-line database) and the Health Effects Assessment Summary Tables (HEAST; USEPA, 1991). The RBACs are very conservative (health-protective) concentrations based on upper-bound estimates of carcinogenicity and toxicity and "reasonable maximum" estimates of inhalation rates ($20 \text{ m}^3/\text{day}$) and exposure, consistent with exposure assumptions described in the Risk Assessment Guidance for Superfund (RAGS) (USEPA, 1989). The RBACs are based on a range of unit risk factors corresponding to 10^4 to 10^6 . A "lifetime excess cancer risk level" of 10^4 to 10^6 corresponds to an 1 in 10,000 to 1 in 1,000,000 chance of getting cancer during a lifetime of exposure. The Reference Concentrations (RfCs) are air concentrations of non-carcinogens considered "safe" for a lifetime of exposure. The RBACs are applicable for long-term exposure. The next two columns of Table 4.4-10 present a range of "typical" state toxic guidelines, both for short-term (1- to 24-hour) and annual averages based on the latest listings of NATICH. A great deal of variability in air toxic guideline concentrations exists from state to state. For comparative purposes, the arithmetic average of the upper and lower bound guideline values were used.

The highest CMP and Basin F metals concentrations for the remediation period and post-remediation period were then compared to the average NATICH guideline value for each metal and averaging period. For example, maximum 24-hour metals concentrations were compared to the average 24-hour guideline value, and the long-term average values of the monitoring period were compared to the average annual guideline value. This method of comparison is a conservative approach, as most of the sample days in the CMP and Basin F database were based on high event, or worst-case

scenarios. The last two columns of Table 4.4-10 show the percentage of the highest CMP and Basin F program maximum 24-hour and average metals concentrations to the average guideline values. All metals concentrations were well below the average NATICH values. Some of the maximum metals concentrations were above the lower bound values (i.e., cadmium, chromium and copper), but the magnitude of these concentrations significantly decreased between the remedial and post-remedial periods. Most maximum long-term concentrations were below those values associated with a lifetime excess cancer risk level of 10^{-4} or, if non-carcinogenic, below the applicable RfC. The only exceptions were chromium, using an extremely conservative assumption that Chromium VI represents chromium in general, and mercury.

Chromium results indicated a 24-hour maximum concentration of $0.2858 \mu\text{g}/\text{m}^3$ which was 5 percent of the average guideline value; the long-term average value was $0.0200 \mu\text{g}/\text{m}^3$, or 6 percent of the annual guideline. However, these levels resulted mainly from the one maximum 24-hour measurement at BF4 during Phase 1. All other maximum chromium measurements at Basin F were considerably lower. The second highest chromium measurement was $0.2083 \mu\text{g}/\text{m}^3$ at BF3, 3 percent of the short-term guideline. Chromium decreased with distance from Basin F, with minimal or no detections during Phases 3 and 4 and some significant concentrations during Phase 5 which were still considerably below Phase 1 measured chromium concentrations.

Basin F appeared to be a localized source of copper and zinc. The short-term measured maximum copper concentration of $1.4980 \mu\text{g}/\text{m}^3$ was 17 percent of the mean 24-hour guideline, while the short-term maximum level of $3.3576 \mu\text{g}/\text{m}^3$ for zinc was 13 percent of the average guideline value. These levels occurred at BF2 and BF5 during Phase 1 and Phase 2, Stage 1. Maximum annual average concentrations for copper and zinc were 2 percent and 10 percent of the annual average guideline, respectively. During Phases 3, 4 and 5, copper and zinc levels decreased to less than 4 percent of the average 24-hour and annual guidelines.

The maximum 24-hour cadmium concentration was measured at the southern perimeter of the Arsenal at AQ5, $0.0281 \mu\text{g}/\text{m}^3$, and was 6 percent of the average short-term guideline. The maximum long-term average of $0.0027 \mu\text{g}/\text{m}^3$ at FC2 was 4 percent of the annual average guideline. Potential sources of cadmium appeared to originate from

outside RMA, although slightly higher cadmium concentrations occurred in the vicinity of Basin F during the post-remedial periods.

Short-term concentrations of arsenic were measured at highest levels at AQ2 and AQ5 during Phases 1 and 2. However, the maximum long-term average was measured at AQ12 during Phase 5. The maximum short-term and long-term arsenic concentrations were 1 percent and 8 percent of the respective average 24-hour and annual guideline values. During Phases 3, 4 and 5, maximum arsenic levels were less than 1 percent of the average 24-hour guideline value and less than 5 percent of the average annual guideline value.

Lead, which is an EPA criteria pollutant, has been a source of concern in the metropolitan Denver area in the past. Lead emissions apparently transport into the Arsenal area from metropolitan Denver. However, the maximum average level measured at AQ7 (during FY89), near the southwest boundary of RMA, was $0.0573 \mu\text{g}/\text{m}^3$, or 4 percent of the Colorado monthly average standard of $1.5 \mu\text{g}/\text{m}^3$.

The maximum 24-hour mercury measurement of $7.3 \mu\text{g}/\text{m}^3$ was at BF2 during Phase 1, and was 18 percent of the average guideline value. The highest long-term average for mercury, $1.8 \mu\text{g}/\text{m}^3$, was also measured at BF2 during the Phase 1 period and was 30 percent of the average annual guideline value.

4.4.6 Summary

Ambient metals concentrations distributed across RMA were generally proportional to TSP concentrations. Relatively high metals concentrations were generally associated with strong and gusty winds; however, exceptions to this trend were apparent due to influences that were sometimes not well-defined. The extreme maxima were associated with poor dispersion conditions and light winds during winter and occurred on days with high particulate levels over Denver. Basin F appeared to be a potential source of chromium, mercury, copper and zinc during Phase 1 remedial activities, but concentrations were localized and decreased rapidly with distance from the source. After remediation, metals levels in the vicinity of Basin F were typical of RMA baseline concentrations. None of the metals concentrations measured during the CMP high event

days nor the Basin F monitoring program indicate significant toxic or contamination levels.

TABLE 4.4-1
SUMMARY OF ROUTINE ICAP METALS
SAMPLING FOR FY91

Station	Samples Scheduled	No. of Samples	Percent Recovery
AQ1	12	7	58
AQ2	12	4	33
AQ3	42	42	100
AQ5	42	42	100
FC1	30	28	93
FC2	30	23	77
FC3	12	12	100
FC4	12	10	83
FC5	30	26	87
QI1	31	28	90
QI2	31	26	84
PROGRAM TOTAL	284	248	87

TABLE 4.4-2

SUMMARY OF CMP METALS CONCENTRATIONS FOR FY91 (in $\mu\text{g}/\text{m}^3$)

PHASE 5	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
	AVERAGE VALUES						
AQ1	*	0.0103	0.0866	*	0.0275	0.0006	*
AQ2	*	0.0114	0.0526	*	0.0460	0.0007	
AQ3	*	0.0070	0.0834	*	0.0227	0.0005	*
AQ4	*	*	0.0643	*	0.0232	*	*
AQ5	0.0012	*	0.0809	0.0137	0.0307	0.0005	*
AQ5C	*	0.0076	0.1616	0.0144	0.0362	0.0004	
AQ6	*	*	0.0525	*	0.0258	*	
AQ7	*	*	0.0674	*	0.0364	0.0007	
AQ8	*	*	0.0770	*	0.0280	0.0017	*
AQ9	*	*	0.0269	*	0.0254	0.0010	*
AQ10	*	*	0.0631	*	0.0307	0.0004	*
AQ11	*	*	0.0571	*	0.0363	0.0023	
AQ12	*	*	0.0264		0.0250	0.0027	
Q11	0.0013	0.0064	0.0867	0.0136	0.0230	0.0004	*
Q12	*	0.0069	0.0569	*	0.0266	0.0005	*

TABLE 4.4-2
(Concluded)

	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
24-HOUR MAXIMUM VALUES							
PHASE 5							
AQ1	*	0.0238	0.1470	*	0.0498	0.0015	*
AQ2	*	0.0166	0.5269	*	0.0524	0.0009	
AQ3	*	0.0209	0.1980	*	0.0431	0.0020	*
AQ4	*	*	0.1130	*	0.0270	*	*
AQ5	0.0028	*	0.3060	0.0361	0.0704	0.0013	*
AQ5C	*	0.0310	0.3120	0.0324	0.0715	0.0010	
AQ6	*	*	0.0597	*	0.0281	*	
AQ7	*	*	0.0777	*	0.0372	0.0009	
AQ8	*	*	0.1130	*	0.0378	0.0026	*
AQ9	*	*	0.0392	*	0.0264	0.0015	*
AQ10	*	*	0.1200	*	0.0337	0.0010	*
AQ11	*	*	0.0853	*	0.0392	0.0042	
AQ12	*	*	0.0289	*	0.0258	0.0050	
QI1	0.0032	0.0137	0.1770	0.0536	0.0505	0.0012	*
QI2	*	0.0191	0.1200	*	0.0810	0.0013	*

* All values below CRL
** Calendar quarter lead standard is 1.5 $\mu\text{g}/\text{m}^3$. Criteria and guidelines for other metals are outlined in Table 4.4-9

TABLE 4.4-3
SYNOPSIS OF FY91 HIGH EVENT MONITORING FOR METALS

Date	Period (24 Hours)	Site Locations
March 1, 1991	0100-2400	AQ1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, FC1, 2, 3, 4, 5
March 19, 1991	0100-2400	AQ1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, FC2, 3, 4, 5
March 25, 1991	0100-2400	AQ1, 3, 4, 5, FC1, 2, 3, 4
July 2, 1991	1100-1000	AQ1, 3, 4, 5, 5C, FC2, Q11, Q12, AQ25 (Mobile E)
July 11, 1991	0100-2400 0800-1600 0800-1600	AQ1, 3, 4, 5, 8, 9 (24 hrs) AQ (Mobile W), AQ36, (Mobile E), AQ36 (Mobile EC) (8 hrs)
July 17, 1991	0100-2400 0800-0800	AQ1 3, 4, 5, 8, 10 (24 hrs) AQ01 (Mobile E), AQ01 (Mobile EC), AQ02 (Mobile W)

TABLE 4.4.4

SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)

	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
PHASE 1							
AVERAGE VALUES							
AQ1	0.000727	*	0.052996	0.026991	0.046046	0.000675	*
AQ2	0.000717	*	0.055301	0.027037	0.041856	0.000615	*
AQ3	0.000471	0.002680	0.108094	0.012940	0.025115	0.000472	*
AQ4	*	*	0.054367	0.010960	0.025140	0.000597	*
AQ5	0.001244	*	0.085670	0.019090	0.030828	0.000482	*
AQ6	0.000321	*	0.061958	0.012233	0.021960	0.000428	*
AQ7	0.000440	*	0.081590	0.017839	0.037150	0.000501	*
AQ8	0.000373	*	0.096483	0.012968	0.024437	0.001454	*
AQ9	0.000296	*	0.062143	0.011499	0.022326	0.000444	*
AQ10	*	*	0.043888	0.009889	0.045437	0.001196	*
AQ11	0.000722	*	0.098143	0.012011	0.027587	0.000535	*
AQ12	0.000286	*	0.077228	0.010950	0.018927	0.000508	*
PHASE 2 - STAGE 1							
AQ3	0.001207	*	0.086848	0.019109	0.025026	0.001007	*
AQ5	0.001326	*	0.089639	0.033968	0.042749	0.001026	*

TABLE 4.4.4
SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)
(Continued)

	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
PHASE 2 - STAGE 2							
AQ1	0.001247	*	0.070093	0.028559	0.047227	0.001289	*
AQ2	0.000787	*	0.065431	0.025759	0.049034	0.001609	*
AQ3	0.000320	*	0.081032	0.009143	0.018193	0.000633	*
AQ4	0.000403	*	0.053458	0.012827	0.022954	0.000709	*
AQ5	0.000485	*	0.080511	0.015271	0.027584	0.000719	*
AQ6	0.000847	*	0.073725	0.016783	0.030312	0.000834	*
AQ7	0.001417	0.004364	0.047011	0.022008	0.146214	0.000833	*
AQ8	0.000841	*	0.063551	0.012492	0.028814	0.002445	*
AQ9	0.000769	*	0.074765	0.013648	0.026143	0.000918	*
AQ10	0.000614	*	0.073663	0.011971	0.028115	0.000719	*
AQ11	0.000394	*	0.053639	0.011119	0.030854	0.000811	*
AQ12	*	0.004098	0.050616	0.011193	0.030488	0.001062	*
PHASE 3							
AQ1	*	*	0.091311	0.015979	0.030726	0.000388	*
AQ2	0.001037	*	0.084262	0.013020	0.035341	0.000445	*

TABLE 4.4-4
SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)
(Continued)

	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
AQ3	0.000346	*	0.116425	0.011695	0.018882	0.000361	*
AQ4	*	*	0.075989	0.006749	0.018877	0.000298	*
AQ5	0.000280	*	0.069275	0.013683	0.022226	0.000358	*
AQ6	*	*	0.086772	0.007364	0.018138	0.000242	*
AQ7	*	*	0.042132	0.057267	0.022382	*	*
AQ8	*	*	0.038484	0.009581	0.020646	0.000936	*
AQ9	*	*	0.054277	0.013668	0.021256	*	*
AQ10	*	*	0.093414	0.007323	0.031296	0.000323	*
AQ11	*	*	0.103172	0.006696	0.036533	0.000310	*
AQ12	*	*	0.126681	0.008199	0.023400	0.000458	*
BF3	*	*	0.048486	0.020637	0.039584	*	*
BF6	*	*	0.058762	0.016919	0.033861	*	*
PHASE 4							
AQ1	0.001048	*	0.091059	0.018319	0.037940	0.000628	*
AQ2	0.002094	*	0.090792	0.033069	0.034711	0.001401	*
AQ3	0.000785	*	0.083162	0.011153	0.021963	0.000496	*

TABLE 4.4-4
SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)
(Continued)

	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
AQ4	0.001025	*	0.074714	0.010841	0.014798	*	*
AQ5	0.001265	0.004398	0.073003	0.015520	0.028181	0.000492	*
AQ6	*	*	0.089974	0.012811	0.020538	0.000610	*
AQ7	*	*	0.061191	0.019978	0.033924	0.000989	*
AQ8	*	*	0.036997	0.011536	0.014929	0.001731	*
AQ9	*	*	0.038945	0.011572	0.016328	0.000511	*
AQ10	*	*	0.073597	0.014415	0.026308	0.000568	*
AQ11	*	*	0.036535	0.011884	0.021087	0.000695	*
AQ12	*	*	0.066461	0.015257	0.024227	0.000663	*
AQ01	*	*	0.039972	*	0.013388	*	*
AQ02	*	*	0.061615	0.022189	0.013400	*	*
AQ23	*	*	0.069083	0.009500	0.027124	*	*
AQ26	0.000681	*	0.092234	0.012298	0.027238	0.000501	*
AQ31	*	*	0.024359	*	0.014793	0.000496	*
AQ35	*	*	0.012033	0.006397	0.009906	*	*
AQ36	*	*	0.056481	*	0.011724	0.002540	*

TABLE 4.4-4
SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)
(Continued).

PHASE 5	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
AQ1	*	0.0103	0.0866	*	0.0275	0.0006	*
AQ2	*	0.0114	0.0526	*	0.0460	0.0007	
AQ3	*	0.0070	0.0834	*	0.0227	0.0005	*
AQ4	*	*	0.0643	*	0.0232	*	*
AQ5	*	*	0.0809	0.0137	0.0307	0.0005	*
AQ5C	*	0.0076	0.1616	0.0144	0.0362	0.0004	
AQ6	*	*	0.0525	*	0.0258	*	
AQ7	*	*	0.0674	*	0.0364	0.0007	
AQ8	*	*	0.0770	*	0.0280	0.0017	*
AQ9	*	*	0.0269	*	0.0254	0.0010	*
AQ10	*	*	0.0631	*	0.0307	0.0004	*
AQ11	*	*	0.0571	*	0.0363	0.0023	
AQ12	*	*	0.0264	*	0.0250	0.0027	
Q11	0.0013	0.0064	0.0867	0.0136	0.0230	0.0004	*
Q12	*	0.0069	0.0569	*	0.0226	0.0005	*

TABLE 4.4-4

SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)
 (Continued)

	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
24-HOUR MAXIMUM VALUES							
PHASE 1							
AQ1	0.001494	*	0.107176	0.043839	0.076761	0.001743	*
AQ2	0.001526	*	0.107616	0.057614	0.062668	0.001664	*
AQ3	0.001913	0.009636	0.287323	0.042410	0.069498	0.001872	*
AQ4	*	*	0.094612	0.013698	0.026226	0.000641	*
AQ5	0.025265	*	0.155868	0.055761	0.084038	0.001826	*
AQ6	0.000533	*	0.132744	0.017265	0.030751	0.000958	*
AQ7	0.001093	*	0.193226	0.022883	0.053563	0.001441	*
AQ8	0.000832	*	0.193701	0.018730	0.034002	0.004122	*
AQ9	0.000746	*	0.160112	0.016663	0.046030	0.000926	*
AQ10	*	*	0.071980	0.010580	0.063189	0.001816	*
AQ11	0.004098	*	0.156818	0.017014	0.065236	0.001154	*
AQ12	0.000697	*	0.124163	0.016409	0.036511	0.001201	*
PHASE 2 - STAGE 1							
AQ3	0.005735	*	0.215672	0.058837	0.070024	0.004237	*

TABLE 4.4.4
SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)
(Continued)

	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury	*
AQ5	0.005276	*	0.192351	0.098442	0.115958	0.004551		*
PHASE 2 - STAGE 2								
AQ1	0.004258	*	0.216952	0.060260	0.094310	0.004875		*
AQ2	0.002686	*	0.088272	0.045431	0.069639	0.005823		*
AQ3	0.001115	*	0.167273	0.028106	0.039742	0.003090		*
AQ4	0.001062	*	0.104382	0.034763	0.049773	0.002623		*
AQ5	0.002923	*	0.123754	0.034095	0.054662	0.003246		*
AQ6	0.001653	*	0.136534	0.027104	0.048587	0.002433		*
AQ7	0.001970		0.107229	0.036759	0.290812	0.002373		*
AQ8	0.001842	*	0.118427	0.029376	0.059744	0.007368		*
AQ9	0.001245	*	0.130539	0.031944	0.054549	0.002713		*
AQ10	0.001884	*	0.173848	0.035278	0.068872	0.002615		*
AQ11	0.001191	*	0.098640	0.029214	0.070754	0.002699		*
AQ12	*	0.012863	0.105145	0.030376	0.078852	0.004283		*
PHASE 3								
AQ1	*	*	0.167180	0.025478	0.039875	0.000574		*

TABLE 4.4.4

SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)
 (Continued)

	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
AQ2	0.003580	*	0.175219	0.015281	0.046939	0.000599	*
AQ3	0.001918	*	0.218258	0.049808	0.031711	0.000882	*
AQ4	*	*	0.104196	0.015888	0.022481	0.000532	*
AQ5	0.001221	*	0.184251	0.033756	0.039404	0.000812	*
AQ6	*	*	0.109768	0.010271	0.018864	0.000426	*
AQ7	*	*	0.042132	0.057267	0.022382	*	*
AQ8	*	*	0.052188	0.020263	0.025110	0.001434	*
AQ9	*	*	0.083477	0.021998	0.021751	*	*
AQ10	*	*	0.126874	0.009303	0.048506	0.000597	*
AQ11	*	*	0.171482	0.007696	0.059436	0.000563	*
AQ12	*	*	0.184211	0.017406	0.028141	0.000626	*
BF3	*	*	0.048486	0.020637	0.039584	*	*
BF6	*	*	0.058762	0.016919	0.033861	*	*
PHASE 4							
AQ1	0.003284	*	0.212262	0.032020	0.072344	0.0002754	*
AQ2	0.004003	*	0.105696	0.034243	0.064570	0.002333	*

TABLE 4.4.4

SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)
 (Continued)

	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
AQ3	0.001947	*	0.245029	0.035001	0.058961	0.001790	*
AQ4	0.002323	*	0.138765	0.014775	0.024909	*	*
AQ5	0.028149	0.015085	0.134883	0.062088	0.108591	0.001892	*
AQ6	*	*	0.184847	0.017478	0.048059	0.001517	*
AQ7	*	*	0.061890	0.026452	0.036551	0.001574	*
AQ8	*	*	0.063838	0.017998	0.025660	0.004142	*
AQ9	*	*	0.062693	0.019163	0.026018	0.001303	*
AQ10	*	*	0.095592	0.019700	0.039461	0.001262	*
AQ11	*	*	0.060755	0.019787	0.026763	0.001485	*
AQ12	*	*	0.067066	0.017010	0.025886	0.001134	*
AQ01	*	*	0.066933	*	0.023233	*	*
AQ02	*	*	0.096168	0.047685	0.024184	*	*
AQ23	*	*	0.096479	0.014291	0.035370	*	*
AQ26	0.001415	*	0.2222301	0.014429	0.052352	0.001218	*
AQ31	*	*	0.024359	*	0.014793	0.000496	*
AQ35	*	*	0.012033	0.006397	0.009906	*	*

TABLE 4.4.4

SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)
 (Continued)

	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
AQ36	*	*	0.144949	*	0.013793	0.004224	*
PHASE 5							
AQ1	*	0.0238	0.1470	*	0.0498	0.0015	*
AQ2	*	0.0166	0.0529	*	0.0524	0.0009	
AQ3	*	0.0209	0.1980	*	0.0431	0.0020	*
AQ4	*	*	0.1130	*	0.0270	*	*
AQ5	0.0028	*	0.3060	0.0361	0.0704	0.0013	*
AQ5C	*	0.0310	0.3120	0.0324	0.0715	0.0010	
AQ6	*	*	0.0597	*	0.0281	*	
AQ7	*	*	0.0777	*	0.0372	0.0009	
AQ8	*	*	0.1130	*	0.0378	0.0026	*
AQ9	*	*	0.0392	*	0.0264	0.0015	*
AQ10	*	*	0.1200	*	0.0337	0.0010	*
AQ11	*	*	0.0853	*	0.0392	0.0042	
AQ12	*	*	0.0289	*	0.0258	0.0050	

TABLE 4.4-4

SUMMARY OF CMP METALS CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)
 (Concluded)

	Cadmium	Chromium	Copper	Lead**	Zinc	Arsenic	Mercury
Q11	0.0032	0.0137	0.1770	0.0536	0.0505	0.0012	*
Q12	*	0.0191	0.1200	*	0.0810	0.0013	*

* All values below CRL

** Calendar quarter lead standard is $1.5 \mu\text{g}/\text{m}^3$. Criteria and guidelines for other metals are outlined in Table 4.4-9

TABLE 4.4-5
METALS DATA SUMMARY FOR 1986-1987
REMEDIAL INVESTIGATION PROGRAM

Metals	Detection Limit ($\mu\text{g}/\text{m}^3$)	Range of Values Above Detection Limits ($\mu\text{g}/\text{m}^3$)	
		From TSP Filters ¹	From PM-10 Filters ²
As	0.003	0.005-0.012(2)*	NHADL**
Cd	0.002	0.002-0.017(21)	0.002-0.003(4)
Cr	0.003	0.003-0.050(19)	NHADL
Cu	0.016	0.026-.912(81)	0.019-0.029(3)
Hg***	0.063	NHADL	NHADL
Pb	0.008	0.010-0.062(66)	0.009-0.037(6)
Zn	0.010	0.128-10.2(11)	NHADL

Source: ESE, 1988.

1 Total number of TSP filters analyzed = 87.

2 Total number of PM-10 filters analyzed = 7.

* Number of hits above detection limits.

** NHADL - No hits above detection limits.

*** Hg collected on Hopcalite™ media.

TABLE 4.4-6

SUMMARY OF BASIN F/IRA-F/RIFS METALS CONCENTRATIONS FOR PHASES 1-5 (in $\mu\text{g}/\text{m}^3$)

	CD	CR	CU	PB	ZN	AS	HG	NH3
AVERAGE VALUES								
Phase 1 (3/22/88 - 12/12/88)								
BF1	0.0006	0.0128	0.1163	0.0148	0.0688	0.0008	0.0008	1.6
BF2	0.0008	0.0101	0.1516	0.0175	0.0727	0.0009	0.0009	1.6
BF2C	0.0005	0.0126	0.1539	0.0172	0.0951	0.0010	0.0010	1.8
BF3	0.0005	0.0176	0.0944	0.0138	0.0776	0.0007	0.0007	1.5
BF4	0.0006	0.0200	0.1258	0.0160	0.0779	0.0009	0.0009	1.5
BF5	0.0006	0.0026	0.0712	0.0144	0.0508	0.0012	0.0012	1.2
BF6	0.0005	0.0032	0.0746	0.0146	0.0472	0.0008	0.0008	280.9
BF7	0.0006	0.0023	0.0791	0.0140	0.0493	0.0007	0.0007	ND
Phase 2 - Stage 1 (12/13/88 - 2/15/89)								
BF1	0.0009	0.0036	0.0569	0.0200	0.2243	0.0008	0.0008	1.3
BF2	0.0006	0.0037	0.0646	0.0220	0.0931	0.0011	0.0011	1.2
BF2C	0.0006	0.0045	0.0687	0.0215	0.1476	0.0013	0.0013	ND
BF3	0.0007	0.0026	0.0566	0.0181	0.1952	0.0009	0.0009	1.2
BF4	0.0007	0.0028	0.0578	0.0202	0.1494	0.0009	0.0009	ND
BF5	0.0006	0.0031	0.0522	0.0159	0.3260	0.0008	0.0008	ND
BF6	0.0006	0.0027	0.0679	0.0167	0.0524	0.0008	0.0008	ND

TABLE 4.4-6
(Continued)

	CD	CR	CU	PB	ZN	AS	HG	NH3
BF7	0.0005	0.0033	0.0684	0.0173	0.1915	0.0007	ND	ND
RIFS1	0.0016	ND	0.0762	0.0397	0.0539	0.0008	ND	ND
RIFS1D	0.0018	ND	0.0851	0.0405	0.0509	0.0011	ND	ND
RIFS2	0.0007	ND	0.0783	0.0248	0.0337	0.0008	ND	ND
Phase 2 - Stage 2 (2/16/89 - 5/5/89)								
BF1	0.0008	0.0026	0.0429	0.0134	0.1052	0.0007	ND	
BF2	0.0006	0.0031	0.0528	0.0148	0.0716	0.0008	ND	
BF2C	0.0005	0.0034	0.0817	0.0152	0.0730	0.0007	ND	
BF3	0.0006	0.0025	0.0546	0.0137	0.1230	0.0007	ND	
BF4	0.0006	0.0029	0.0533	0.0135	0.0430	0.0007	ND	
BF5	0.0023	0.0022	0.0377	0.0134	0.0832	ND	ND	
BF6	0.0004	0.0032	0.0445	0.0145	0.0403	0.0008	ND	
BF7	0.0006	0.0024	0.0701	0.0133	0.0814	ND	ND	
RIFS1	0.0008	0.0031	0.0999	0.0232	0.0413	0.0007	ND	
RIFS1D	0.0012	ND	0.1072	0.0231	0.1105	0.0005	ND	
RIFS2	0.0008	ND	0.0899	0.0218	0.0363	0.0009	ND	
Phase 3 (5/6/89 - 9/30/89)								
FC1	0.0013	ND	0.1434	0.0255	0.0217	0.0005	ND	
FC2	0.0008	ND	0.0961	0.0152	0.0182	0.0003	ND	

TABLE 4.4-6
(Continued)

	CD	CR	CU	PB	ZN	AS	HG	NH3
FC2D	0.0007	ND	0.1366	0.0140	0.0195	0.0003	ND	
BF3/FC3	0.0007	ND	0.1081	0.0147	0.0204	0.0003	ND	
BF4/FC4	0.0007	ND	0.1095	0.0148	0.0196	0.0004	ND	
BF5	0.0006	ND	0.1148	0.0176	0.0250	0.0003	ND	
FC5	0.0003	ND	0.1516	0.0092	0.0257	0.0002	ND	
BF7	0.0006	ND	0.1466	0.0164	0.0197	0.0004	ND	
RIFS1	0.0007	ND	0.1362	0.0183	0.0303	0.0003	ND	
Phase 4 (10/1/89 - 9/30/90)								
FC1	0.0005	0.0027	0.0994	0.0100	0.0216	0.0005	0.4403	
FC2	0.0004	0.0026	0.0903	0.0099	0.0223	0.0005	0.3791	
FC2D	0.0004	ND	0.0930	0.0097	0.0212	0.0004	0.4730	
FC3	0.0004	ND	0.0494	0.0102	0.0207	0.0005	0.4651	
FC4	0.0004	ND	0.0741	0.0102	0.0236	0.0007	0.4271	
FC5	0.0003	0.0030	0.0710	0.0108	0.0252	0.0006	0.3607	
Phase 5 (10/1/90 - 9/30/91)								
FC1	*	0.0066	0.1047	0.0134	0.0248	0.0004	*	
FC2	*	0.0100	0.0948	*	0.0204	0.0006	*	
FC3	0.0023	*	0.0657	0.0125	0.0235	0.0005	*	
FC4	*	*	0.0666	*	0.0252	0.0005	*	

TABLE 4.4-6
(Continued)

FC5	*	CD	CR	CU	PB	ZN	AS	HG	NH3
24-HOUR MAXIMUM VALUES									
Phase 1 (3/22/88 - 12/12/88)									
BF1	0.0032	0.1520	0.3851	0.0258	0.5471	0.0025	4.7		
BF2	0.0149	0.1350	1.4980	0.0614	0.8106	0.0037	7.3		
BF2C	0.0019	0.1350	0.6349	0.0397	0.5623	0.0026	7.3		
BF3	0.0036	0.2083	0.5760	0.0292	0.5054	0.0018	7.3		
BF4	0.0037	0.2858	0.5349	0.0317	0.8651	0.0024	5.0		
BF5	0.0022	0.0087	0.1758	0.0434	0.2557	0.0136	2.1	821.9	
BF6	0.0015	0.0123	0.1413	0.0260	0.1449	0.0018	4.9	366.8	
BF7	0.0035	0.0038	0.1174	0.0261	0.2284	0.0013	6.3	ND	
Phase 2 - Stage 1 (12/13/88 - 2/15/89)									
BF1	0.0037	0.0149	0.0839	0.0499	0.9703	0.0024	1.5		
BF2	0.0016	0.0083	0.1226	0.0428	0.4959	0.0031	3.0		
BF2C	0.0013	0.0082	0.0983	0.0366	0.4762	0.0025	ND		
BF3	0.0016	0.0037	0.0858	0.0430	0.9151	0.0032	2.1		
BF4	0.0016	0.0038	0.1004	0.0436	1.1316	0.0026	ND		
BF5	0.0016	0.0075	0.0975	0.0260	3.3576	0.0028	ND		
BF6	0.0013	0.0044	0.1065	0.0312	0.1476	0.0012	ND		

TABLE 4.4-6
(Continued)

	CD	CR	CU	PB	ZN	AS	HG	NH3
BF7	0.0012	0.0110	0.1116	0.0247	1.0643	0.0012	ND	ND
RIFS1	0.0067	ND	0.1490	0.1080	0.1110	0.0038	ND	ND
RIFS1D	0.0065	ND	0.1570	0.0674	0.0655	0.0039	ND	ND
RIFS2	0.0032	ND	0.1680	0.0779	0.0676	0.0034	ND	ND
Phase 2 - Stage 2 (2/16/89 - 5/5/89)								
BF1	0.0069	0.0037	0.0804	0.0249	0.5420	0.0024	ND	ND
BF2	0.0015	0.0093	0.1112	0.0311	0.6865	0.0025	ND	ND
BF2C	0.0009	0.0082	0.1178	0.0239	0.3462	0.0018	ND	ND
BF3	0.0016	0.0032	0.0983	0.0244	0.6185	0.0024	ND	ND
BF4	0.0015	0.0080	0.1025	0.0257	0.1040	0.0025	ND	ND
BF5	0.0199	0.0029	0.0694	0.0191	0.4289	ND	ND	ND
BF6	0.0008	0.0064	0.0936	0.0292	0.0819	0.0017	ND	ND
BF7	0.0019	0.0035	0.1039	0.0182	0.5766	ND	ND	ND
RIFS1	0.0040	0.0141	0.1600	0.0553	0.0854	0.0025	ND	ND
RIFS1D	0.0042	ND	0.1360	0.0381	0.3330	0.0007	ND	ND
RIFS2	0.0021	ND	0.1310	0.0385	0.0501	0.0023	ND	ND
Phase 3 (5/6/89 - 9/31/89)								
FC1	0.0033	ND	0.1910	0.0489	0.0272	0.0006	ND	ND
FC2	0.0043	ND	0.1610	0.0493	0.0268	0.0006	ND	ND

TABLE 4.4-6
(Continued)

	CD	CR	CU	PB	ZN	AS	HG	NH3
FC2D	0.0029	ND	0.2290	0.0502	0.0280	0.0005	ND	
BF3/FC3	0.0033	ND	0.1420	0.0475	0.0280	0.0006	ND	
BF4/FC4	0.0040	ND	0.1490	0.0482	0.0296	0.0005	ND	
BF5	0.0021	ND	0.1750	0.0471	0.0393	0.0005	ND	
FC5	0.0007	ND	0.2160	0.0141	0.0350	0.0004	ND	
BF7	0.0013	ND	0.1940	0.0411	0.0285	0.0006	ND	
RIFS1	0.0021	ND	0.2360	0.0401	0.0465	0.0007	ND	
Phase 4 (10/1/89 - 9/30/90)								
FC1	0.0033	0.0052	0.2600	0.0360	0.0600	0.0031	2.70	
FC2	0.0038	0.0051	0.2100	0.0380	0.0600	0.0035	0.94	
FC2D	0.0040	ND	0.1900	0.0380	0.0610	0.0016	2.60	
FC3	0.0042	ND	0.0980	0.0440	0.0670	0.0040	1.10	
FC4	0.0035	ND	0.1400	0.0420	0.0730	0.0072	2.00	
FC5	0.0028	0.0150	0.1500	0.0410	0.0710	0.0030	1.00	
Phase 5 (10/1/90 - 9/30/91)								
FC1	*	0.0161	0.2570	0.0368	0.0550	0.0011		
FC2	*	0.0549	0.1740	*	0.0372	0.0032	*	

TABLE 4.4-6
(Concluded)

	CD	CR	CU	PB	ZN	AS	HG	NH3
FC3	0.0173	*	0.1910	0.0280	0.0547	0.0011	*	*
FC4	*	*	0.1280	*	0.0560	0.0012	*	*
FC5	*	0.0253	0.1370	0.0888	0.0556	0.0026	*	*
Legend:	CD	Cadmium	ZN	Zinc				
	CR	Chromium	AS	Arsenic				
	CU	Copper	HG	Mercury				
	PB	Lead	NH3	Ammonia				

TABLE 4.4-7
**OBSERVED MAXIMUM METALS CONCENTRATIONS AND
ASSOCIATED WIND SPEEDS AT CMP SITES**

Metal	Maximum Concentration ($\mu\text{g}/\text{m}^3$)	Phase	Date	Maximum Wind Speed Gust (mph)	Average Wind Speed (mph)	# Hours Gust > 22 mph	Dominant Wind Direction
STATION AQ1							
Cadmium	0.00426	P2-S2	03-11-89	14.9	7.8	0	SSW
Chromium	0.0238	P5	07-03-91	15.2	5.3	0	SW
Copper	0.21695	P2-S2	03-11-89	14.9	7.8	0	SSW
Lead	0.06026	P2-S2	03-11-89	14.9	7.8	0	SSW
Zinc	0.09431	P2-S2	03-11-89	14.9	7.8	0	SSW
Arsenic	0.00487	P2-S2	03-11-89	14.9	14.9	8	WNW
Mercury	ND	--	--	--	--	--	--
STATION AQ2							
Cadmium	0.00400	P4	06-28-90	23.7	11.4	0	SSW
Chromium	0.0166	P5	03-01-91	39.4	11.4	7	ENE
Copper	0.17522	P3	05-28-89	25.8	10.8	3	SSW
Lead	0.05761	P1	03-22-88	25.4	9.2	5	NNE
Zinc	0.06964	P2-S2	03-11-89	14.9	7.8	0	SSW
Arsenic	0.00582	P2-S2	03-17-89	49.5	14.9	8	WNW
Mercury	ND	--	--	--	--	--	--
STATION AQ3							
Cadmium	0.00573	P2-S1	01-28-89	39.7	14.6	13	N
Chromium	0.0209	P5	09-04-91	27.6	6.5	2	S
Copper	0.28732	P1	09-24-88	14.1	8.6	0	S
Lead	0.05884	P2-S1	02-09-89	17.6	5.9	0	S
Zinc	0.07002	P2-S1	01-04-89	16.9	6.3	0	S

TABLE 4.4-7
OBSERVED MAXIMUM METALS CONCENTRATIONS AND
ASSOCIATED WIND SPEEDS AT CMP SITES
(Continued)

Metal	Maximum Concentration ($\mu\text{g}/\text{m}^3$)	Phase	Date	Maximum Wind Speed Gust (mph)	Average Wind Speed (mph)	# Hours Gust >22 mph	Dominant Wind Direction
Arsenic	0.00424	P2-S1	02-15-89	20.3	6.0	0	NNW
Mercury	ND	--	--	--	--	--	--
STATION AQ4							
Cadmium	0.00232	P4	01-07-90	26.9	9.0	0	SSW
Chromium	ND	--	--	--	--	--	--
Copper	0.13876	P4	06-28-90	23.7	11.4	0	SSW
Lead	0.03476	P2-S2	03-11-89	14.9	7.8	0	SSW
Zinc	0.04977	P2-S2	03-11-89	14.9	7.8	0	SSW
Arsenic	0.00262	P2-S2	03-11-89	14.9	7.8	0	SSW
Mercury	ND	--	--	--	--	--	--
STATION AQ5							
Cadmium	0.02815	P4	12-12-89	24.1	10.7	0	W
Chromium	0.01508	P4	05-07-90	39.9	10.4	1	SSW
Copper	0.3060	P5	01-24-91	25.9	6.4	1	NE
Lead	0.09844	P2-S1	02-09-89	17.6	5.9	0	S
Zinc	0.11596	P2-S1	01-04-89	16.9	6.3	0	S
Arsenic	0.00455	P2-S1	02-15-89	20.3	6.0	0	NNW
Mercury	ND	--	--	--	--	--	--
STATION AQ6							
Cadmium	0.00165	P2-S2	04-22-89	28.8	12.2	6	SSW
Chromium	ND	--	--	--	--	--	--

TABLE 4.4-7
OBSERVED MAXIMUM METALS CONCENTRATIONS AND
ASSOCIATED WIND SPEEDS AT CMP SITES
(Continued)

Metal	Maximum Concentration ($\mu\text{g}/\text{m}^3$)	Phase	Date	Maximum Wind Speed Gust (mph)	Average Wind Speed (mph)	# Hours Gust > 22 mph	Dominant Wind Direction
Copper	0.18485	P4	06-28-90	23.7	11.4	0	SSW
Lead	0.02710	P2-S2	03-11-89	14.9	7.8	0	SSW
Zinc	0.04859	P2-S2	03-11-89	14.9	7.8	0	SSW
Arsenic	0.00243	P2-S2	03-11-89	14.9	7.8	0	SSW
Mercury	ND	--	--	--	--	--	--
STATION AQ7							
Cadmium	0.00197	P2-S2	04-22-89	28.8	12.2	6	SSW
Chromium	0.01021	P2-S2	03-11-89	14.9	7.8	0	SSW
Copper	0.19323	P1	04-03-89	26.8	11.9	4	WSW
Lead	0.05727	P3	06-21-89	31.7	10.5	7	SW
Zinc	0.29081	P2-S2	03-11-89	14.9	7.8	0	SSW
Arsenic	0.00237	P2-S2	03-11-89	14.9	7.8	0	SSW
STATION AQ8							
Cadmium	0.00184	P2-S2	04-04-89	41.9	11.3	7	NW
Chromium	ND	--	--	--	--	--	--
Copper	0.19370	P1	04-03-88	26.8	11.9	4	WSW
Lead	0.02938	P2-S2	03-11-89	14.9	7.8	0	SSW
Zinc	0.05974	P2-S2	04-22-89	28.8	12.2	6	SSW
Arsenic	0.00737	P2-S2	05-04-89	50.8	9.0	6	ENE
Mercury	ND	--	--	--	--	--	--

TABLE 4.4-7
OBSERVED MAXIMUM METALS CONCENTRATIONS AND
ASSOCIATED WIND SPEEDS AT CMP SITES
(Continued)

Metal	Maximum Concentration ($\mu\text{g}/\text{m}^3$)	Phase	Date	Maximum Wind Speed Gust (mph)	Average Wind Speed (mph)	# Hours Gust >22 mph	Dominant Wind Direction
STATION AQ9							
Cadmium	0.00124	P2-S2	03-11-89	41.9	7.8	0	SSW
Chromium	ND	--	--	--	--	--	--
Copper	0.16011	P1	11-04-88	36.4	23.9	7	WNW
Lead	0.03194	P2-S2	03-11-89	14.9	7.8	0	SSW
Zinc	0.05455	P2-S2	03-11-89	14.9	7.8	0	SSW
Arsenic	0.00271	P2-S2	03-11-89	14.9	7.8	0	SSW
Mercury	ND	--	--	--	--	--	--
STATION AQ10							
Cadmium	0.00188	P2-S2	03-11-89	14.9	7.8	0	SSW
Chromium	ND	--	--	--	--	--	--
Copper	0.17385	P2-S2	03-11-89	14.9	7.8	0	SSW
Lead	0.03528	P2-S2	03-11-89	14.9	7.8	0	SSW
Zinc	0.06887	P2-S2	03-11-89	14.9	7.8	0	SSW
Arsenic	0.00261	P2-S2	03-11-89	14.9	7.8	0	SSW
Mercury	ND	--	--	--	--	--	--
STATION AQ11							
Cadmium	0.00410	P1	05-03-88	33.0	6.5	0	ENE
Chromium	ND	--	--	--	--	--	--
Copper	0.17148	P3	07-03-89	47.8	12.0	8	SSW
Lead	0.02921	P2-S2	03-11-89	14.9	7.8	0	SSW

TABLE 4.4-7
OBSERVED MAXIMUM METALS CONCENTRATIONS AND
ASSOCIATED WIND SPEEDS AT CMP SITES
(Concluded)

Metal	Maximum Concentration ($\mu\text{g}/\text{m}^3$)	Phase	Date	Maximum Wind Speed Gust (mph)	Average Wind Speed (mph)	# Hours Gust > 22 mph	Dominant Wind Direction
Zinc	0.07075	P2-S2	03-11-89	14.9	7.8	0	SSW
Arsenic	0.00420	P5	03-19-91	45.0	17.4	13	SSW
Mercury	ND	--	--	--	--	--	--
STATION AQ12							
Cadmium	0.00070	P1	04-21-88	25.7	10.8	5	NE
Chromium	0.01286	P2-S2	03-11-89	14.9	7.8	0	SSW
Copper	0.18421	P3	05-28-89	25.8	10.8	3	SSW
Lead	0.03038	P2-S2	03-11-89	14.9	7.8	0	SSW
Zinc	0.07885	P2-S2	03-11-89	14.9	7.8	0	SSW
Arsenic	0.0050	P5	03-19-91	45.0	17.4	13	SSW
Mercury	ND	--	--	--	--	--	--

TABLE 4.4-8

SEASONAL METALS AND ARSENIC CONCENTRATIONS BY SITE (in $\mu\text{g}/\text{m}^3$)

Season	Site	Cadmium	Chromium	Copper	Lead	Zinc	Arsenic
AVERAGE							
Fall	AQ3	0.00047	*	0.07664	0.01380	0.02557	0.00050
	AQ5	0.00154	*	0.07819	0.02353	0.03689	0.00060
	AQ5B	0.00155	*	0.13499	0.02373	0.03917	0.00065
Winter	AQ3	0.00085	*	0.08633	0.01206	0.02306	0.00058
	AQ5	0.00092	0.00673	0.10800	0.01953	0.03811	0.00062
	AQ5B	0.00087	*	0.11476	0.02037	0.04399	0.00077
Spring	AQ3	0.00078	0.00628	0.08119	0.01140	0.01932	0.00050
	AQ5	0.00125	0.00445	0.07668	0.01378	0.02395	0.00049
	AQ5B	0.00120	0.00445	0.11494	0.01326	0.02697	0.00047
Summer	AQ3	0.00087	0.00523	0.12037	0.01227	0.02433	0.00054
	AQ5	0.00100	*	0.08428	0.01404	0.02792	0.00046
	AQ5B	0.00105	*	0.14583	0.01362	0.02913	0.00041
24-HOUR MAXIMUM							
Fall	AQ3	0.00191	*	0.18462	0.04241	0.06950	0.00133
	AQ5	0.02815	*	0.13472	0.06209	0.10859	0.00189
	AQ5B	0.02671	*	0.25871	0.05838	0.10198	0.00383
Winter	AQ3	0.00574	*	0.24503	0.05884	0.07002	0.00424
	AQ5	0.00528	0.03100	0.25700	0.09844	0.11596	0.00455
	AQ5B	0.00551	*	0.31200	0.09193	0.18504	0.00428
Spring	AQ3	0.00192	0.01380	0.21826	0.04981	0.05903	0.00148
	AQ5	0.02527	0.01509	0.15587	0.03376	0.06150	0.00117
	AQ5B	0.02352	0.02659	0.27700	0.02948	0.05570	0.00142
Summer	AQ3	0.00178	0.02090	0.28732	0.03423	0.04549	0.00199

TABLE 4.4-8

**SEASONAL METALS AND ARSENIC CONCENTRATIONS BY SITE (in $\mu\text{g}/\text{m}^3$)
(Concluded)**

Season	Site	Cadmium	Chromium	Copper	Lead	Zinc	Arsenic
	AQ5	0.00751	*	0.18425	0.03032	0.07040	0.00175
	AQ5B	0.00695	*	0.24453	0.03605	0.05588	0.00166

Includes data for CMP FY88, FY89, FY90, and FY91.

TABLE 4.4-9

**MAXIMUM CONCENTRATIONS MEASURED AT RMA FOR CMP AND
BASIN F/IRA-F CONCURRENT PROGRAMS ($\mu\text{g}/\text{m}^3$)**

Metal	Maximum Long-Term Average Concentration	Location	Phase	Maximum 24-Hour Concentration		Location	Phase
Arsenic	0.0025	AQ36	P4	0.0136		BF5	P1
Cadmium	0.0027	FC2	P3	0.0281		AQ5	P4
Chromium	0.0200	BF4	P1	0.2858		BF4	P1
Copper	0.1539	BF2	P1	1.4980		BF2	P1
Lead	0.0573	AQ7	P3	0.0984		AQ5	PS-S1
Zinc	0.3260	BF5	P2-S1	3.3576		BF5	P2-S1
Mercury	1.8000	BF2	P1	7.3000		BF2	P1

TABLE 4.4-10
RMA TARGET METALS COMPOUNDS COMPARISON TO HEALTH GUIDELINES

Target Name	CAS #	TLV ($\mu\text{g}/\text{m}^3$) ¹	TLV/420 ($\mu\text{g}/\text{m}^3$)	EPA Standards ($\mu\text{g}/\text{m}^3$)	Chronic RBAC* ($\mu\text{g}/\text{m}^3$)		Typical Guidelines ($\mu\text{g}/\text{m}^3$)		Maximum ($\mu\text{g}/\text{m}^3$)	% of Guideline ⁴		
					Lifetime Excess Cancer Risk Level 10^{-6}	Lifetime Excess Cancer Risk Level 10^{-4}	RfC	Short- term	Annual	24-Hr	Long- Term	24-Hr
PHASES 1 AND 2												
Arsenic	7440-38-2	200	0.48	0.02	0.0002	N/A	0.5-5	0.0002- 0.07	0.0136	0.0016	0.49	4.56
Cadmium	7440-43-9	50	0.12	0.06	0.0006	N/A	0.01-1	0.00056 -.12	0.0281	0.0023	5.56	3.82
Chromium	7440-47-3	50	0.12	0.008 ⁶	0.00008 ⁶	N/A ⁶	0.25-12	0.000083 .68	0.2858	0.0200	4.67	5.88
Copper	7440-50-8	1000	2.38	N/A	N/A	N/A	0.24-17	0.1-20	1.4980	0.1539	17.38	1.53
Lead	7439-92-1	150	0.36	1.5 ²	N/A	N/A	1.5 ²		0.0984	0.0340	N/A	2.27 ⁴
Zinc	7440-66-6	5000 ³	11.90	N/A	N/A	N/A	12-39.3	0.03-6.55	3.3576	0.3260	13.09	9.90
Mercury	7439-97-6	50	0.12	N/A	0.0003	0.024-83	0.01-12	7.3	1.8	17.59	29.98	
PHASES 3, 4, AND 5												
Arsenic	7440-38-2	200	0.48	0.02	0.0002	N/A	0.5-5	0.0002- 0.7	0.0072	0.0027	0.26	7.70
Cadmium	7440-43-9	50	0.12	0.06	0.0006	N/A	0.01-1	0.00056 -.12	0.0281	0.0027	5.56	4.48
Chromium	7440-47-3	50	0.12	0.008 ⁶	0.00008 ⁶	N/A ⁶	0.25-12	0.000083 .68	0.0549	0.0114	0.90	3.35
Copper	7440-50-8	1000	2.38	N/A	N/A	N/A	0.24-17	0.1-20	0.3120	0.1616	3.62	1.61

TABLE 4.4-10
RMA TARGET METALS COMPOUNDS COMPARISON TO HEALTH GUIDELINES
(Concluded)

Target Name	CAS #	TLV ($\mu\text{g}/\text{m}^3$) ¹	TLV/420 ($\mu\text{g}/\text{m}^3$)	EPA Standards ($\mu\text{g}/\text{m}^3$)	Chronic RBAC*		Typical Guidelines ($\mu\text{g}/\text{m}^3$)	Maximum ($\mu\text{g}/\text{m}^3$)	% of Guideline ⁴
					Lifetime Excess Cancer Risk Level 10^{-6}	Lifetime Excess Cancer Risk Level 10^{-4}			
Lead	7439-92-1	150	0.36	1.5 ²	N/A	N/A	1.5 ²	0.0888	0.0573
Zinc	7440-66-6	5000 ³	11.90	N/A	N/A	N/A	12.39 ³	0.03-6.55	0.1086
Mercury	7439-97-6	50	0.12	N/A	N/A	0.0003	0.024-83	0.01-12	0.4730
							2.70	6.51	7.88

¹ TLVs are taken from either ACGIH or NIOSH (TLV is the Threshold limit Value).

² Based on EPA 3-month average standard.

³ Zinc TLV is for zinc oxide.

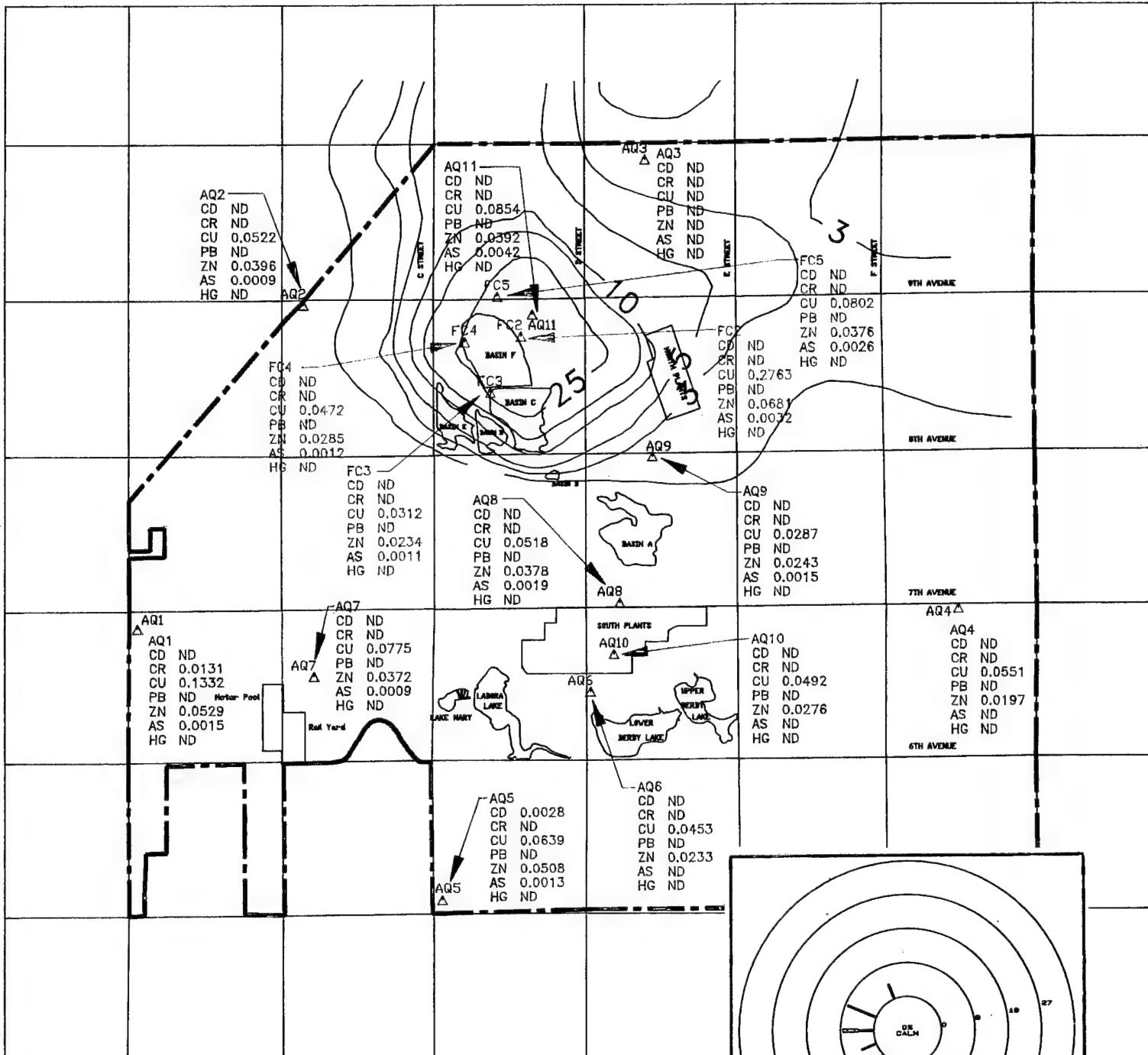
⁴ Based on arithmetic average of upper and lower guideline values.

⁵ Based on EPA standard for lead.

⁶ Chronic RBACs based on values for Chromium VI.

RBAC* Risk-based concentration for long-term (lifetime) residential exposures. RBACs for carcinogens are derived from unit risks reported in EPA's Integrated Risk Information System (IRIS) database or EPA's Health Effects Assessment Summary Tables (HEAST, 1992). RBACs for noncarcinogens are Reference Concentrations (RCFs) reported in the same document.

N/A
Not Available



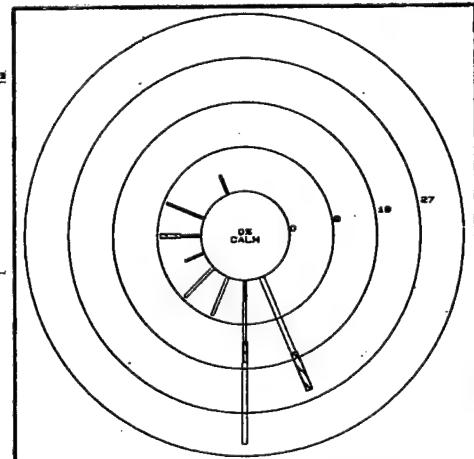
AQ8
△ Comprehensive Monitoring Location

FC2
△ CMP FC Sites
(Formerly IRA-F)

AS = Arsenic
CD = Cadmium
CR = Chromium
CU = Copper
PB = Lead
ZN = Zinc
HG = Mercury
ND = Non-Detectable

24 Hour Maximum (ug/m³)

Source: Basin F



5000 0 5000 10000
SCALE Feet

Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

Metals Results and x/Q Dispersion for 03/19/91
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb DATE : 5/5/92

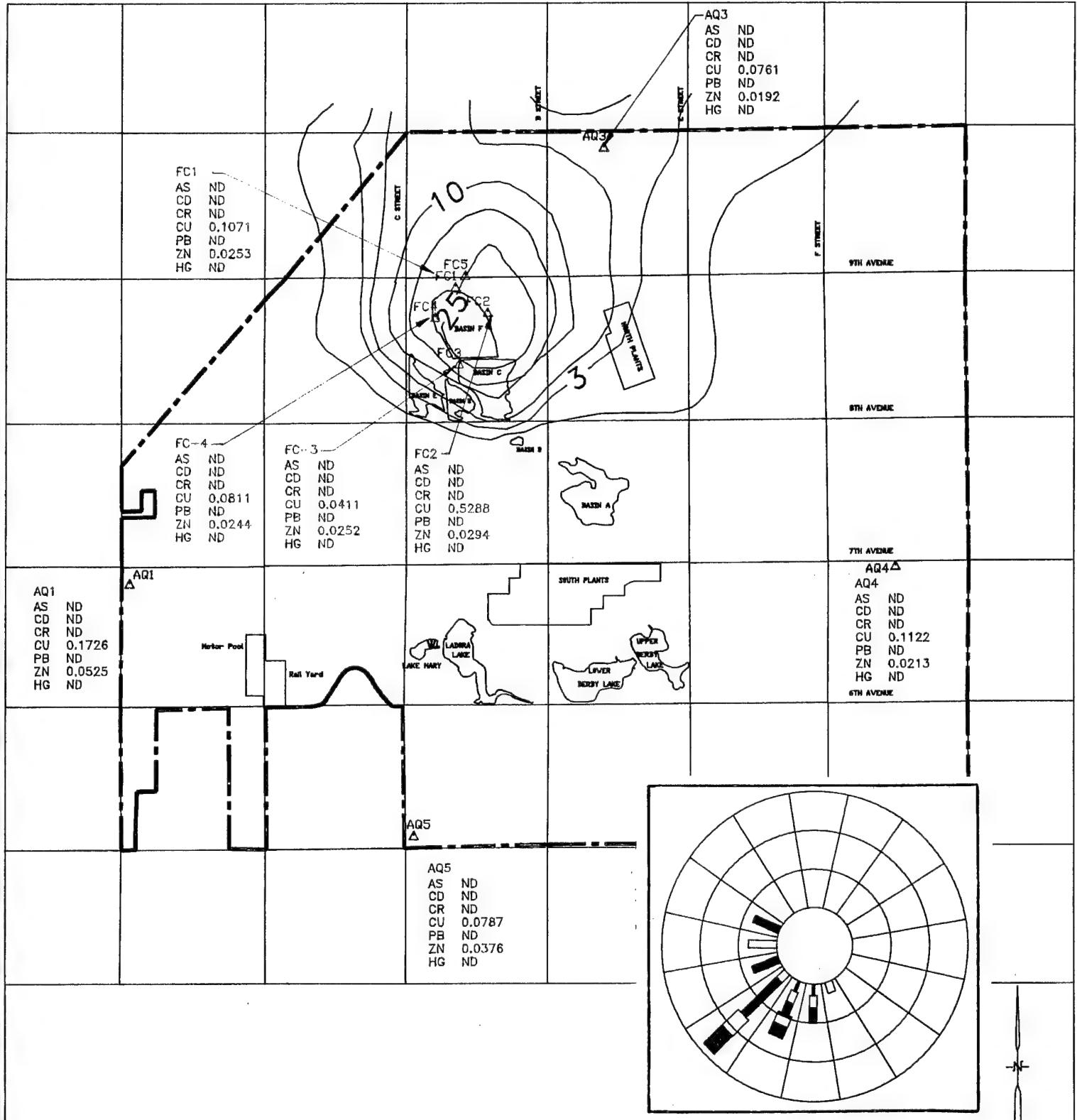
CHKD BY : DATE :

PROJECT NO:

22787E

FIG. NO :

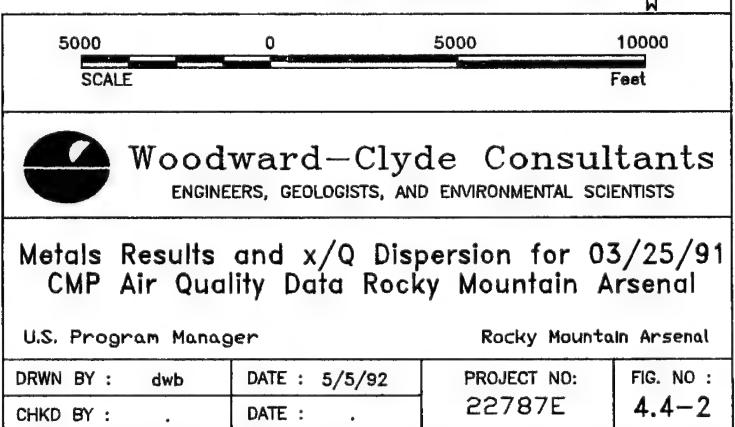
4.4-1

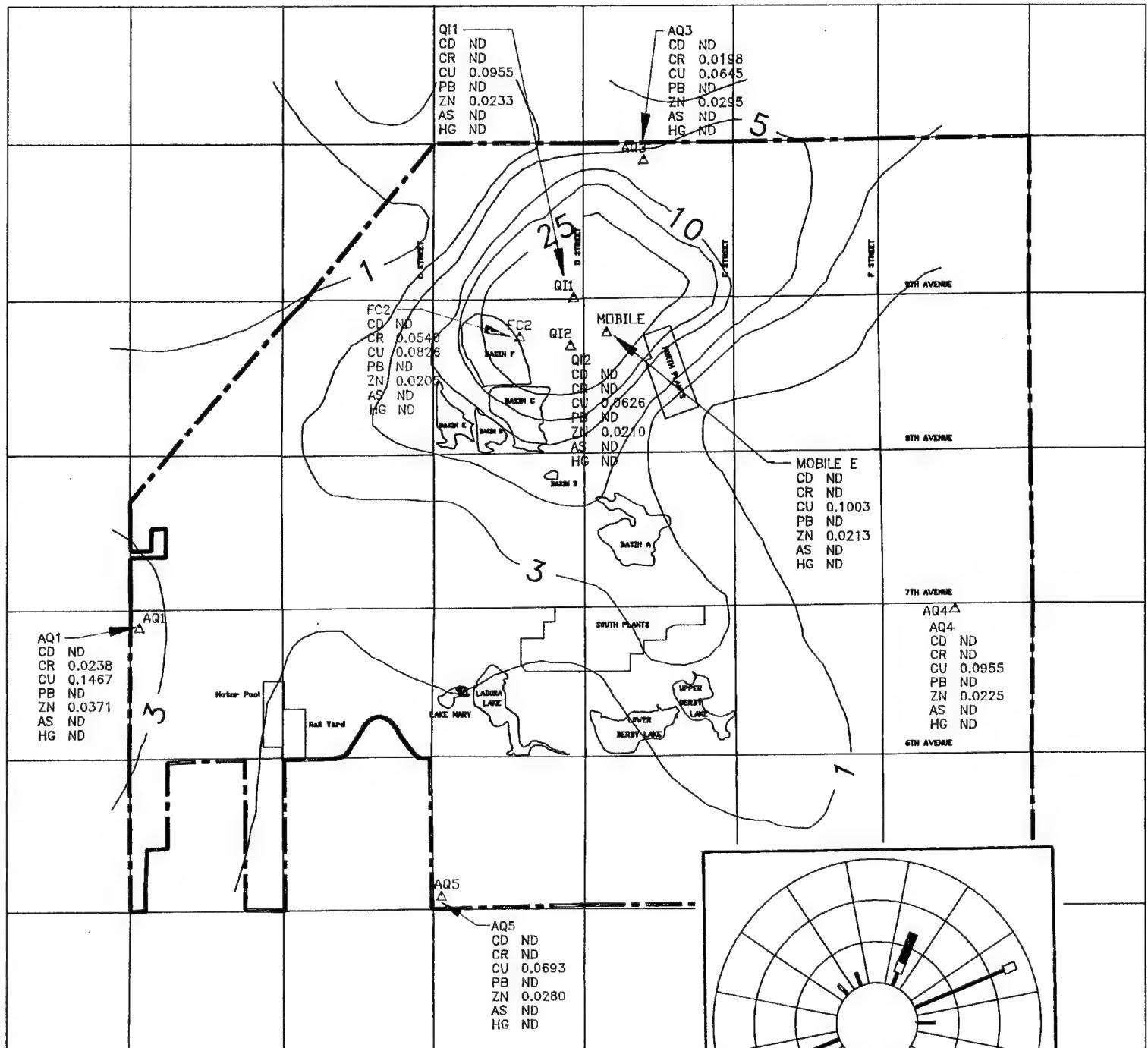


LEGEND

FC3	△	CMP FC Sites (Formerly IRA-F)
AQ5	△	Comprehensive Monitoring Location
AS	=	Arsenic
CD	=	Cadmium
CR	=	Chromium
CU	=	Copper
PB	=	Lead
ZN	=	Zinc
HG	=	Mercury
ND	=	Non-Detectable

Annual Average ($\mu\text{g}/\text{m}^3$)
Source: Basin F





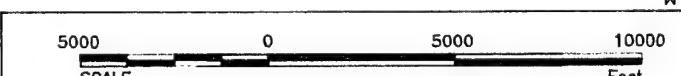
QI2 ▲ Comprehensive Monitoring Location

FC2
△ CMP FC Sites
(Formerly IRA-F)

AS	Arsenic
CD	Cadmium
CR	Chromium
CU	Copper
PB	Lead
ZN	Zinc
HG	Mercury
ND	Non-Detectable

24 Hour Maximum (ug/m³)

Source: Quench Incinerator



The logo for Woodward-Clyde Consultants consists of a circular emblem on the left containing a stylized leaf or flower design. To the right of the emblem, the company name "Woodward-Clyde Consultants" is written in a bold, sans-serif font. Below the main name, the words "ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS" are printed in a smaller, all-caps, sans-serif font.

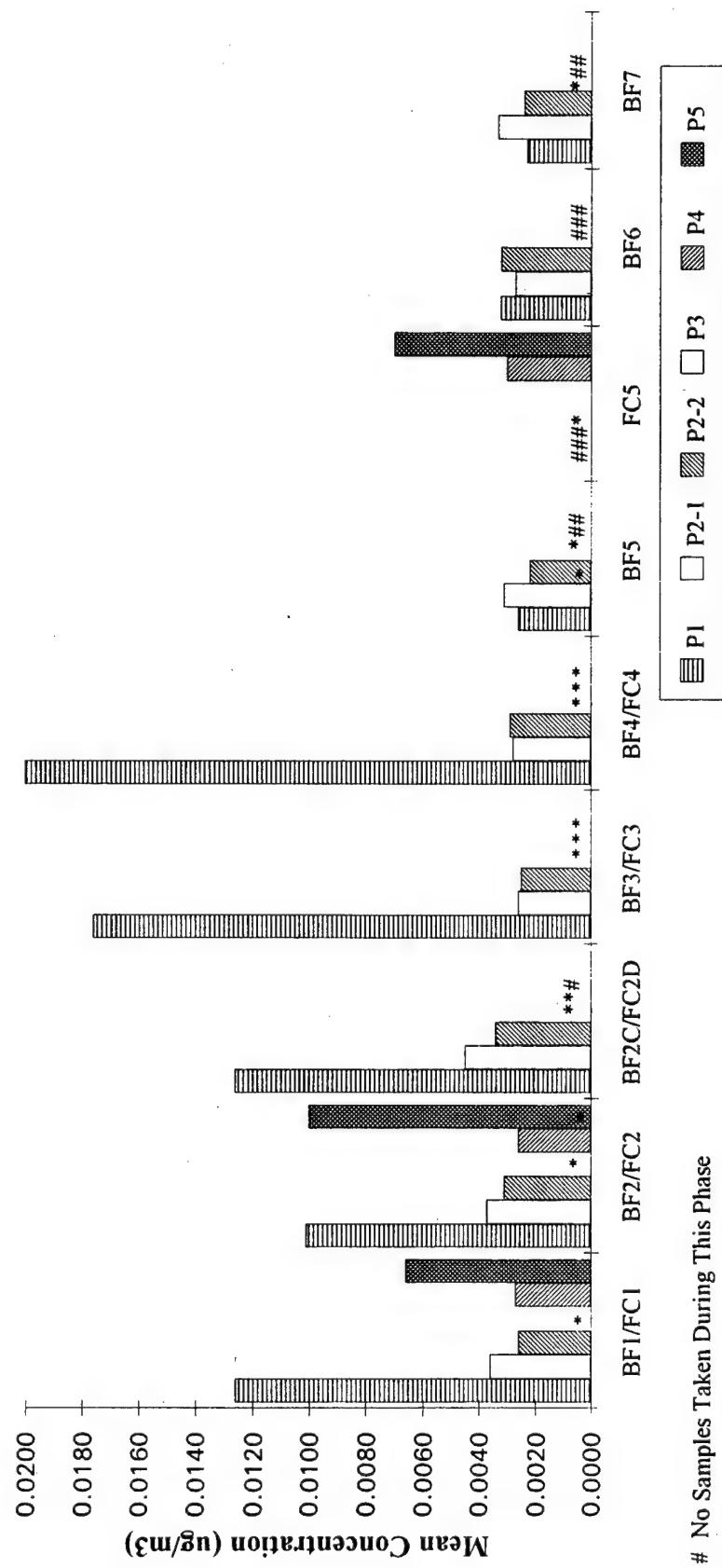
Metals Results and x/Q Dispersion for 07/02/91
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

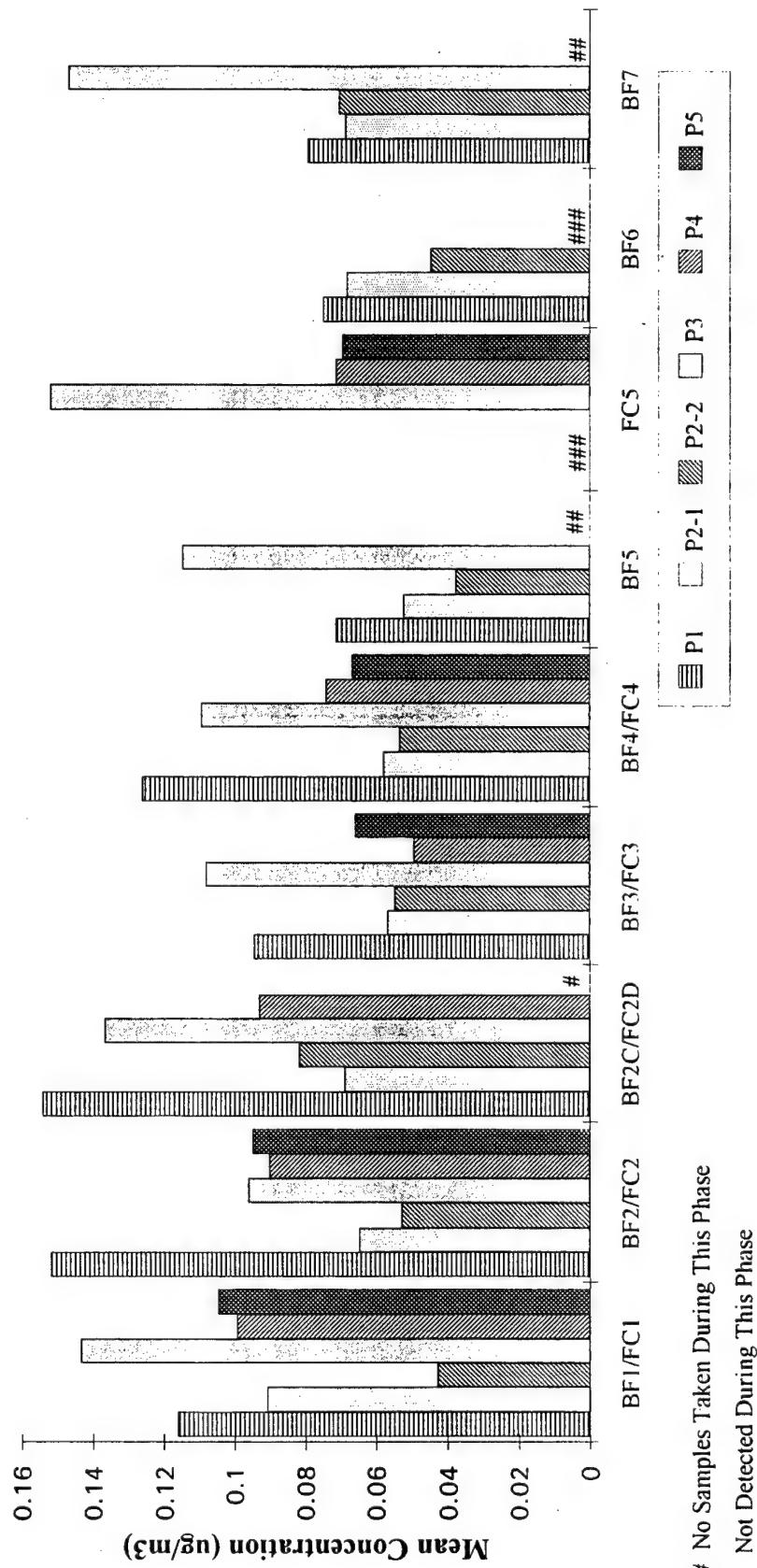
DRWN BY : dwb DATE : 5/5/

PROJECT NO: FIG. NO :
22787E 4.4-3

Chromium Results by Phase

Job No. :	22787E
Prepared by :	TRH
Date :	10/22/92

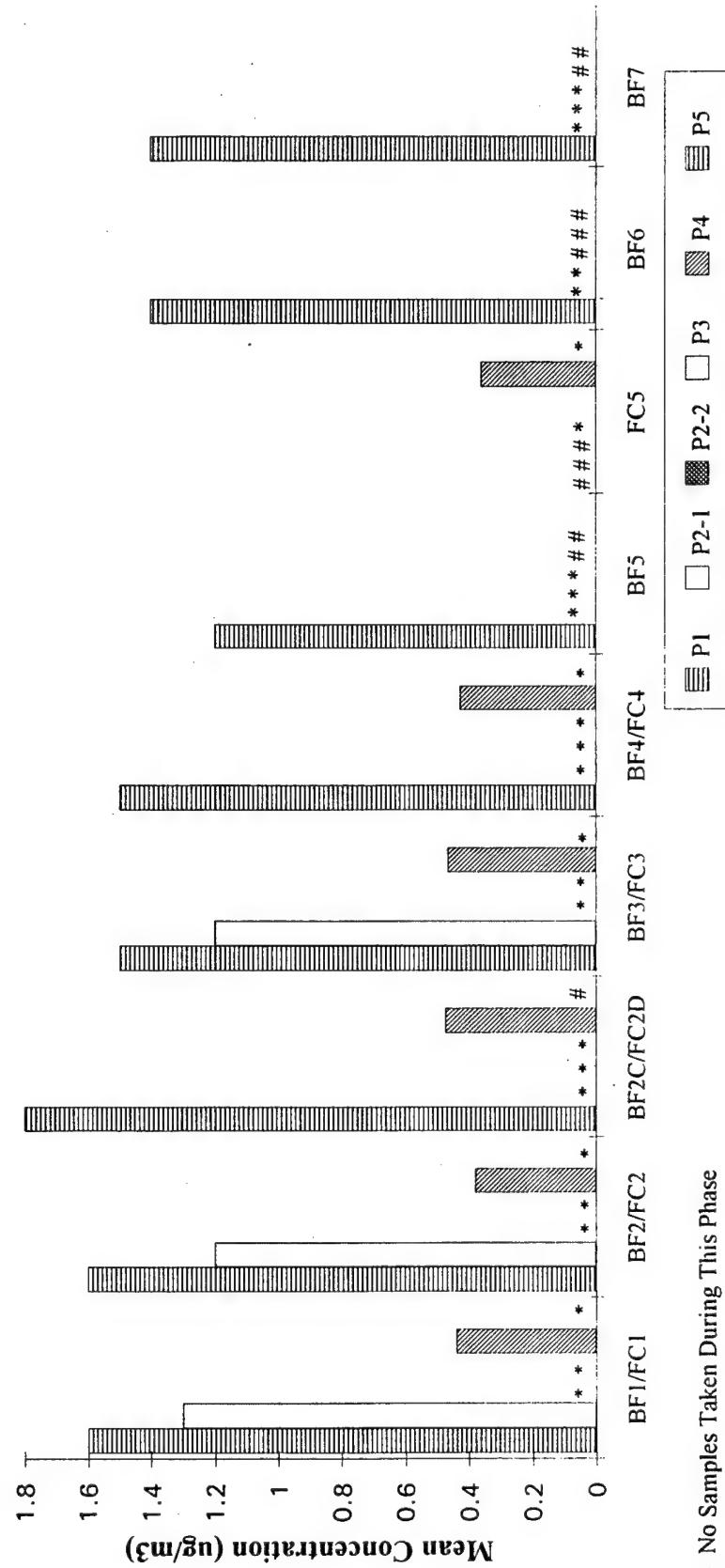
CHROMIUM RESULTS BY PHASE

Copper Results by Phase

Job No. :	22787E
Prepared by :	TRH
Date :	10/22/92

COPPER RESULTS BY PHASE

Mercury Results by Phase

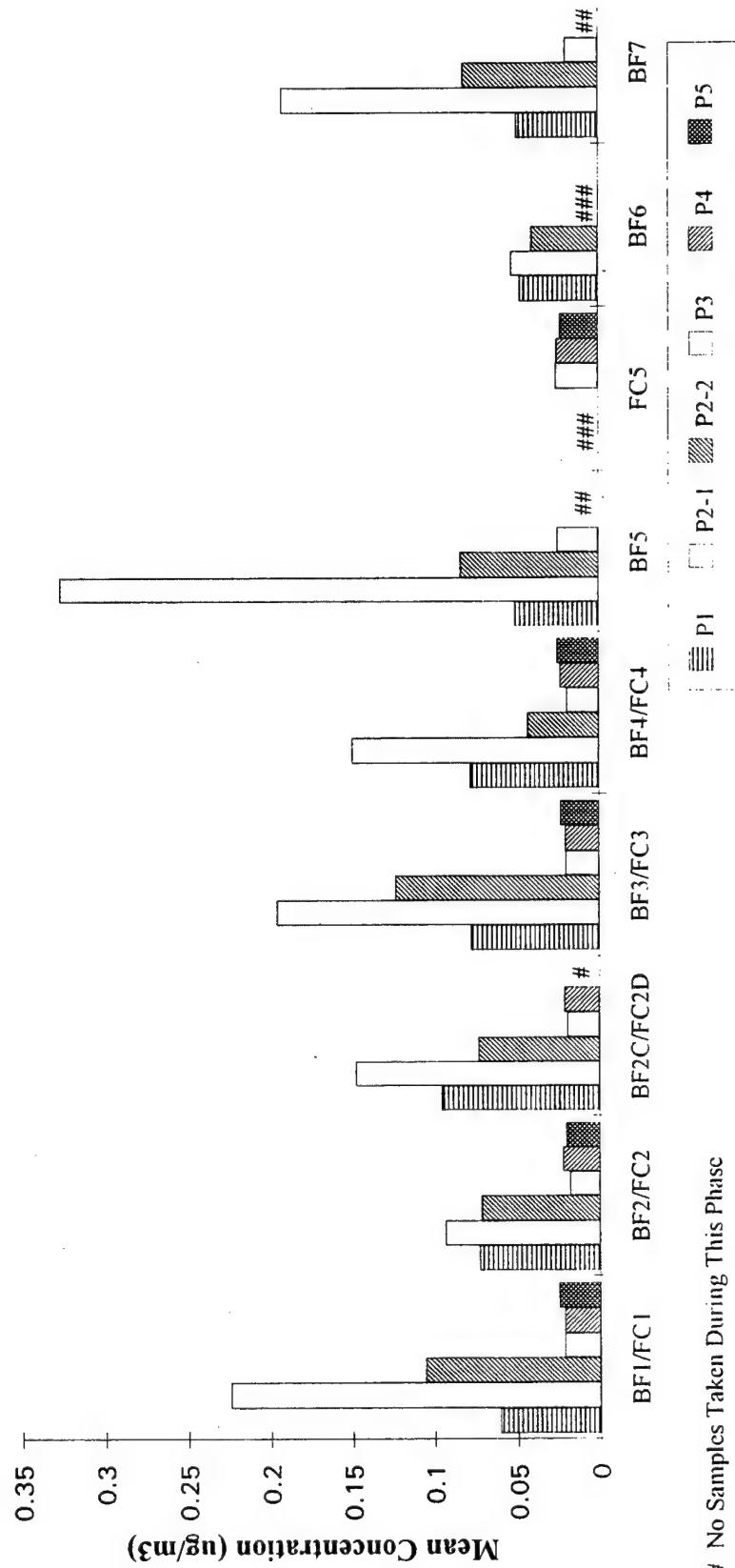


Job No. :	22787E
Prepared by :	TRH
Date :	10/22/92

MERCURY RESULTS BY PHASE



Zinc Results by Phase



No Samples Taken During This Phase

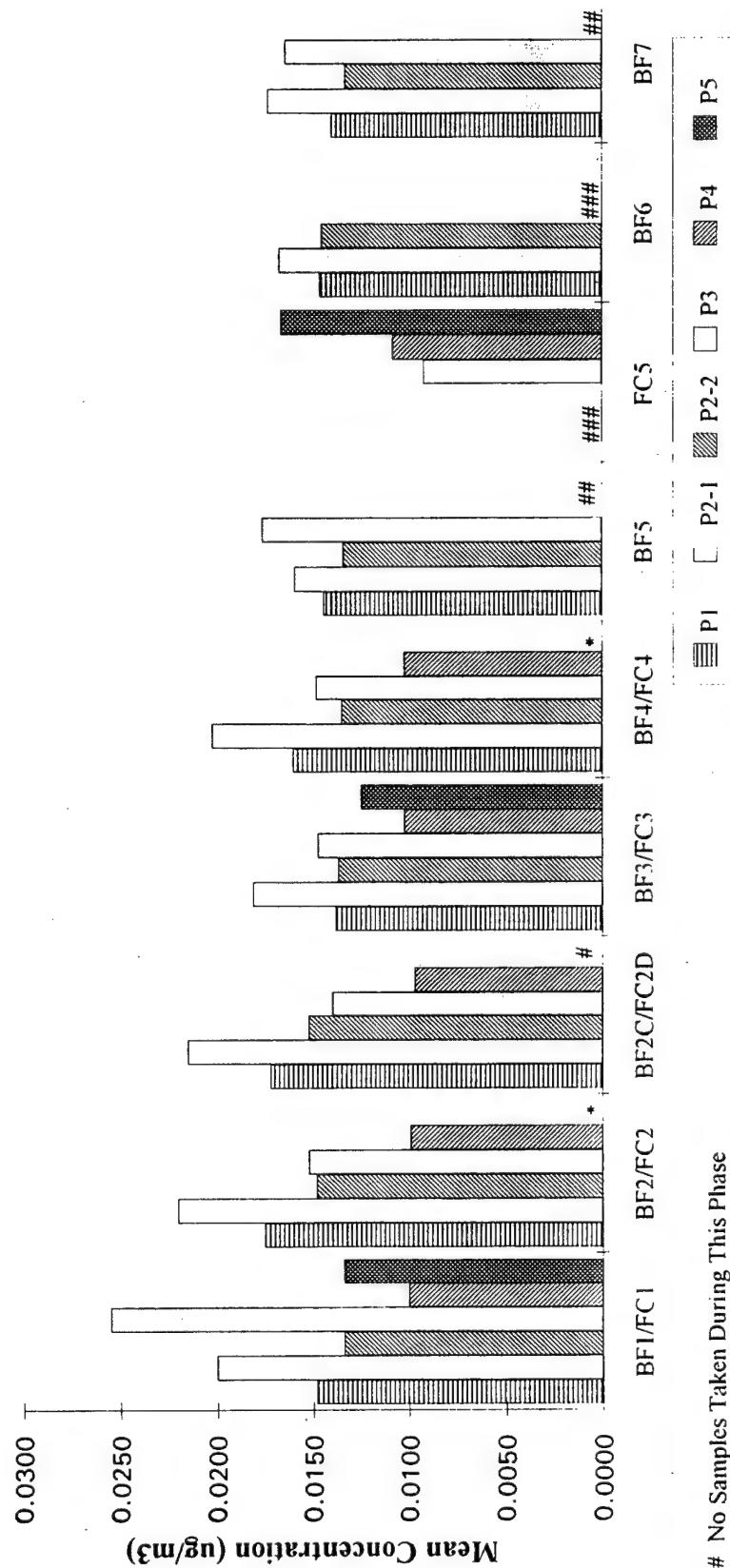
* Not Detected During This Phase

Job No. :	22787E
Prepared by :	TRH
Date :	10/22/92

ZINC RESULTS BY PHASE



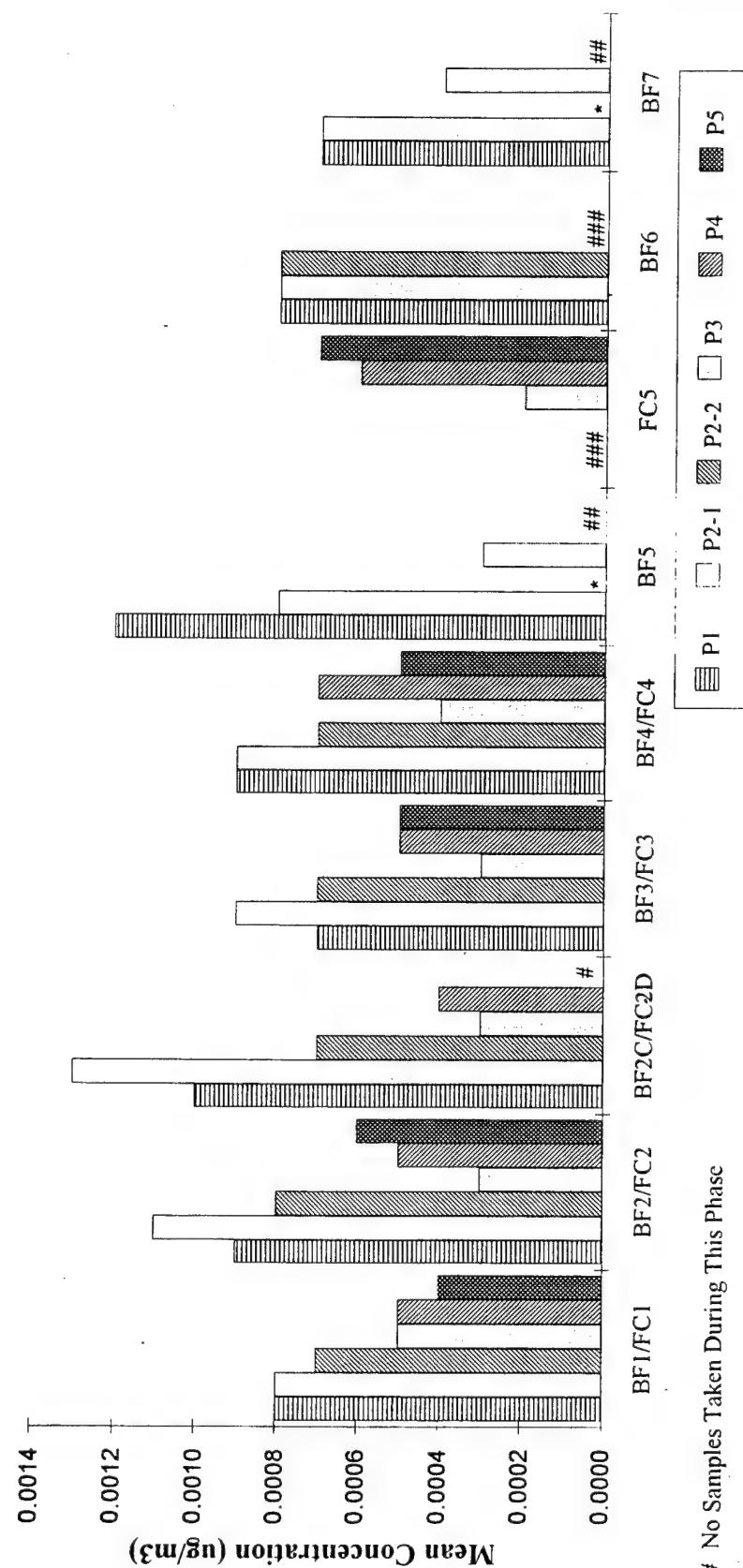
Lead Results by Phase



Job No. :	22787E
Prepared by :	TRH
Date :	10/22/92

LEAD RESULTS BY PHASE

Arsenic Results by Phase

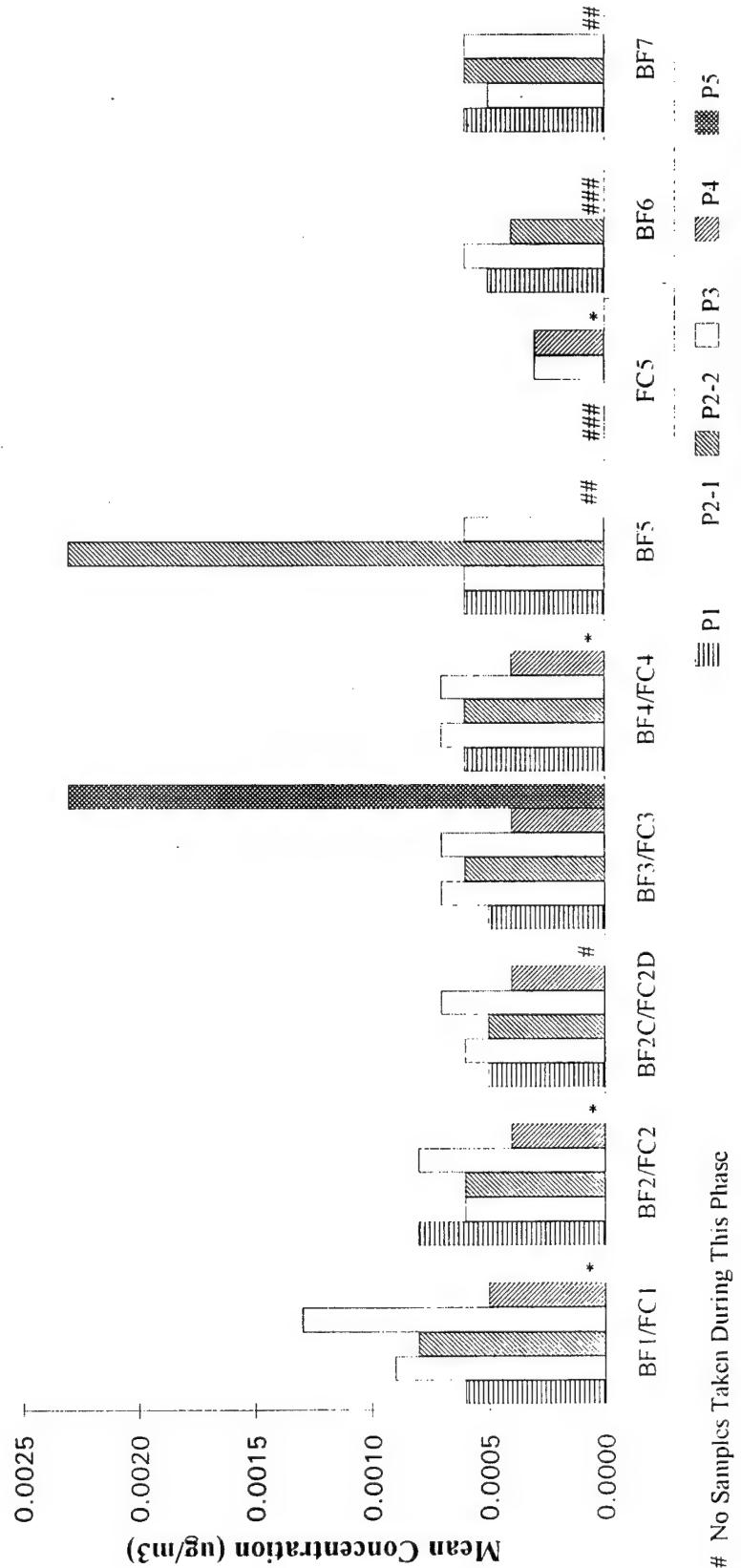


Job No. :	22787E
Prepared by :	TRH
Date :	10/22/92

ARSENIC RESULTS BY PHASE



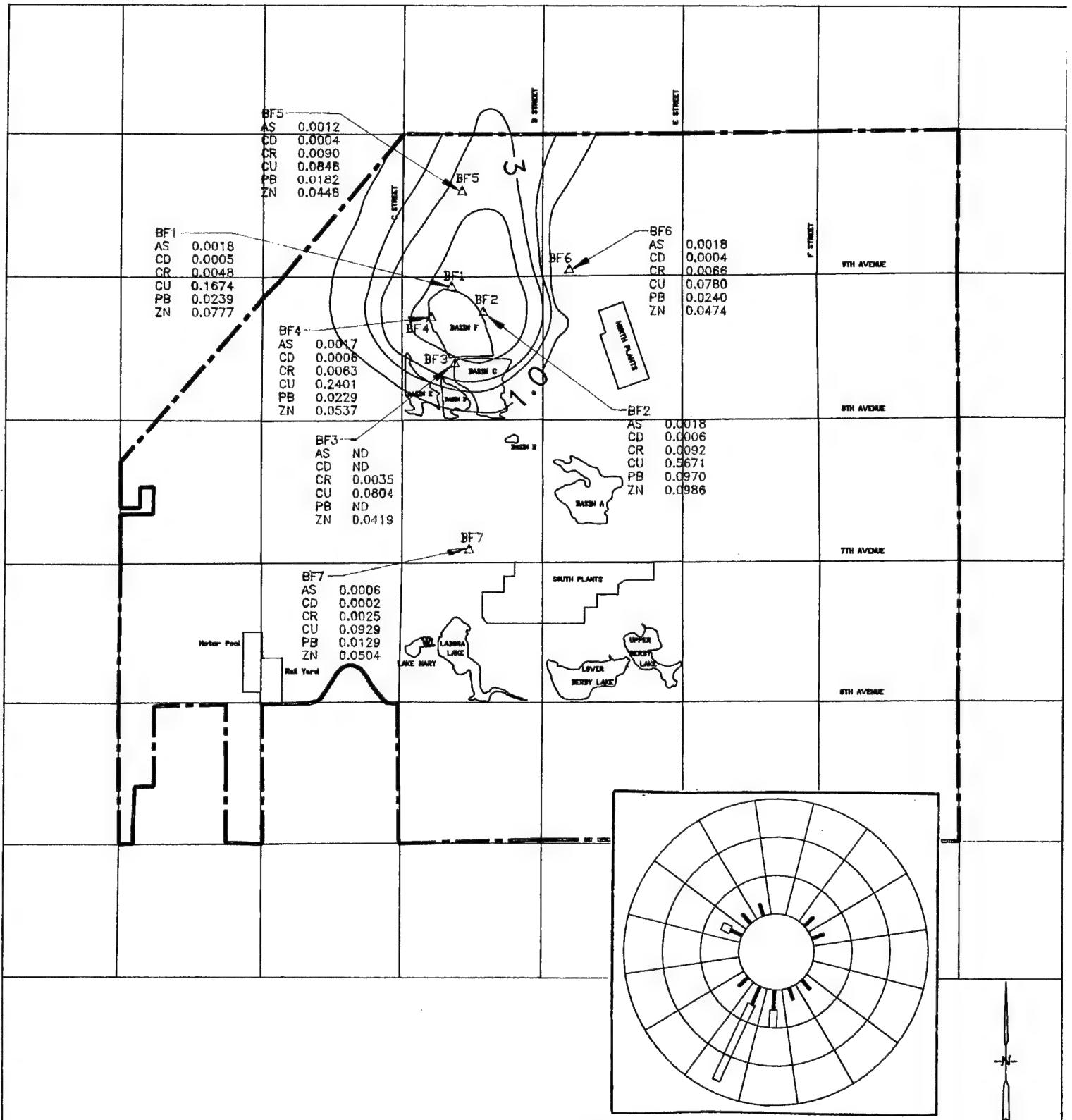
Cadmium Results by Phase



Job No. :	22787E
Prepared by :	TRH
Date :	10/22/92

CADMIUM RESULTS BY PHASE





LEGEND

BF3 △ BASIN F Monitoring Location

AS = Arsenic
 CD = Cadmium
 CR = Chromium
 CU = Copper
 PB = Lead
 ZN = Zinc
 ND = Non-Detectable

Annual Average / 24 Hour Maximum ($\mu\text{g}/\text{m}^3$)

5000 0 5000 10000
SCALE Feet



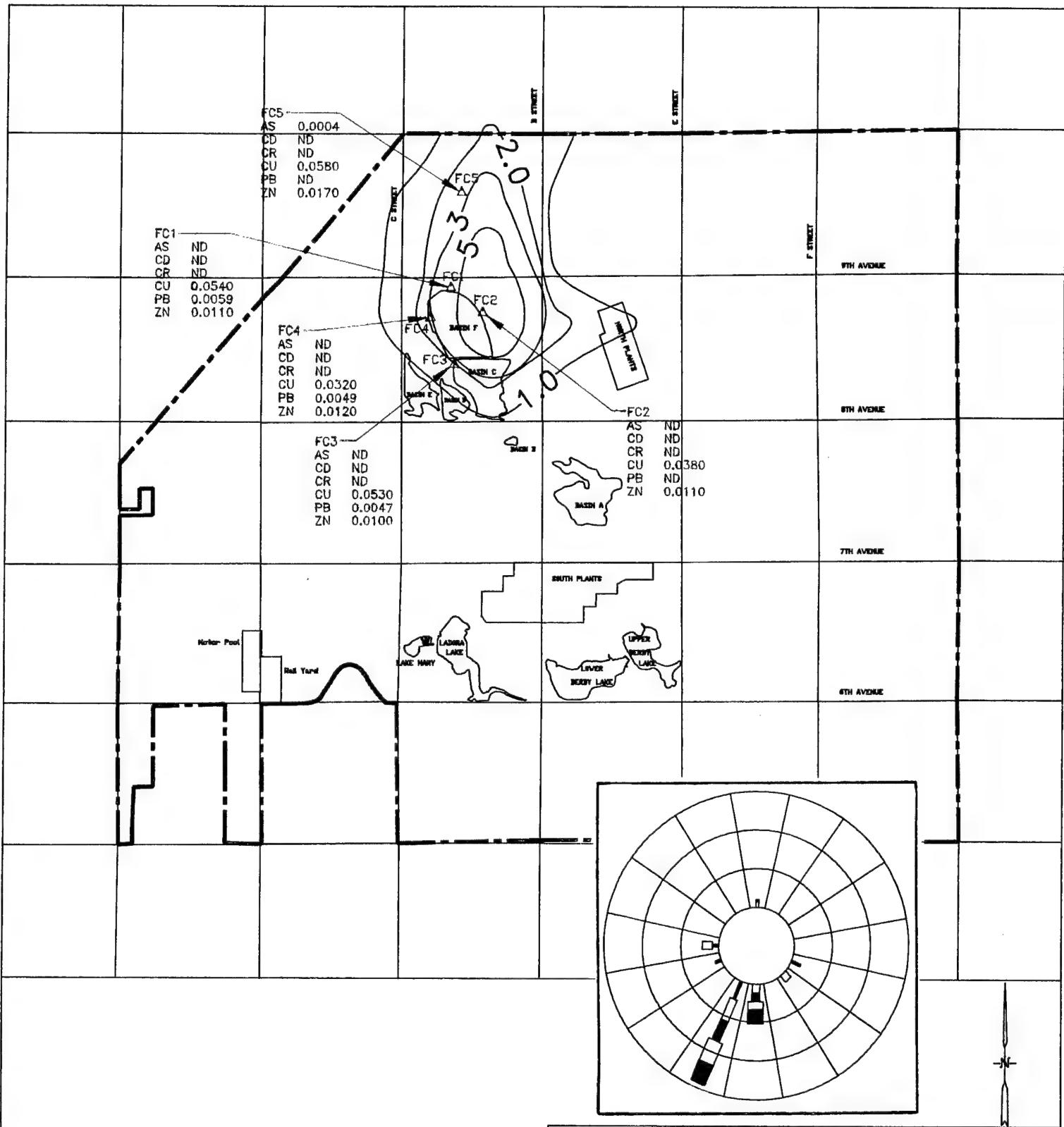
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

x/Q Dispersion and Basin F Metals for 9/06/88
Basin F Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	dwb	DATE :	5/5/92	PROJECT NO:	
CHKD BY :	.	DATE :	.	FIG. NO :	4.4-11



LEGEND

FC3 IRA-F Monitoring Location

AS = Arsenic
CD = Cadmium
CR = Chromium
CU = Copper
PB = Lead
ZN = Zinc
ND = Non-Detectable

Annual Average / 24 Hour Maximum ($\mu\text{g}/\text{m}^3$)

5000 0 5000 10000
SCALE Feet



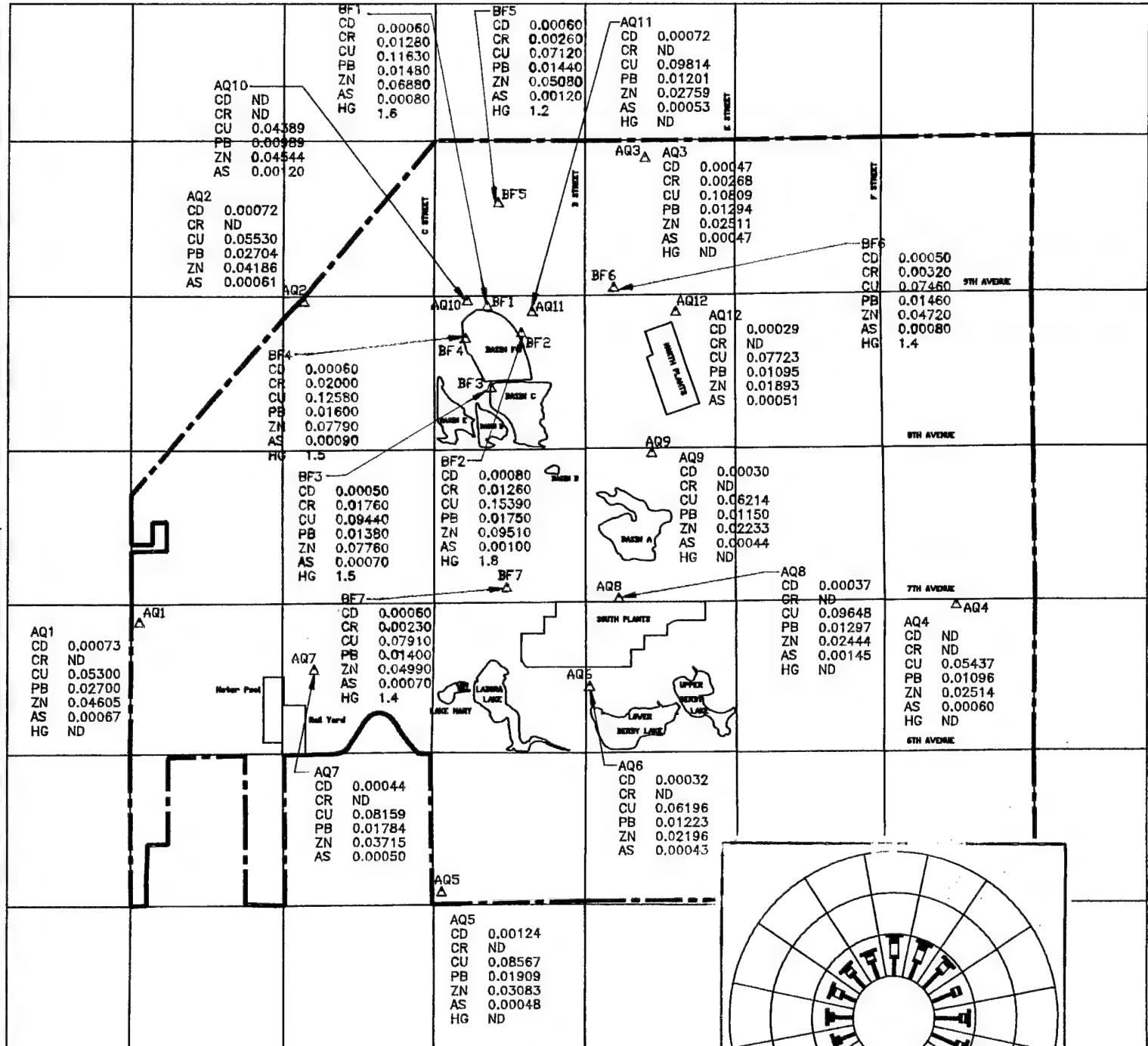
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

x/Q Dispersion and IRA-F Metals for 9/10/90
IRA-F Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb	DATE : 5/5/92	PROJECT NO:	FIG. NO :
CHKD BY : .	DATE : .	22787E	4.4-12



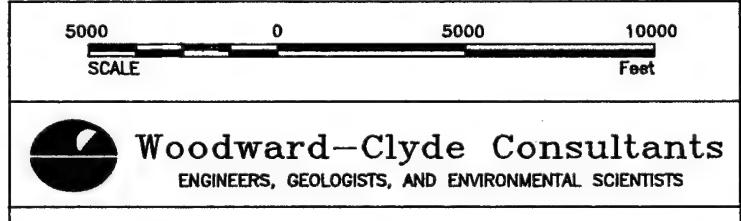
LEGEND

BF3 △ BASIN F Monitoring Location

AQ1 △ Comprehensive Monitoring Location

AS = Arsenic
CD = Cadmium
CR = Chromium
CU = Copper
PB = Lead
ZN = Zinc
ND = Non-Detectable

Annual Average (ug/m³)



Composite Metals Analysis for Phase 1 CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb DATE : 5/5/92

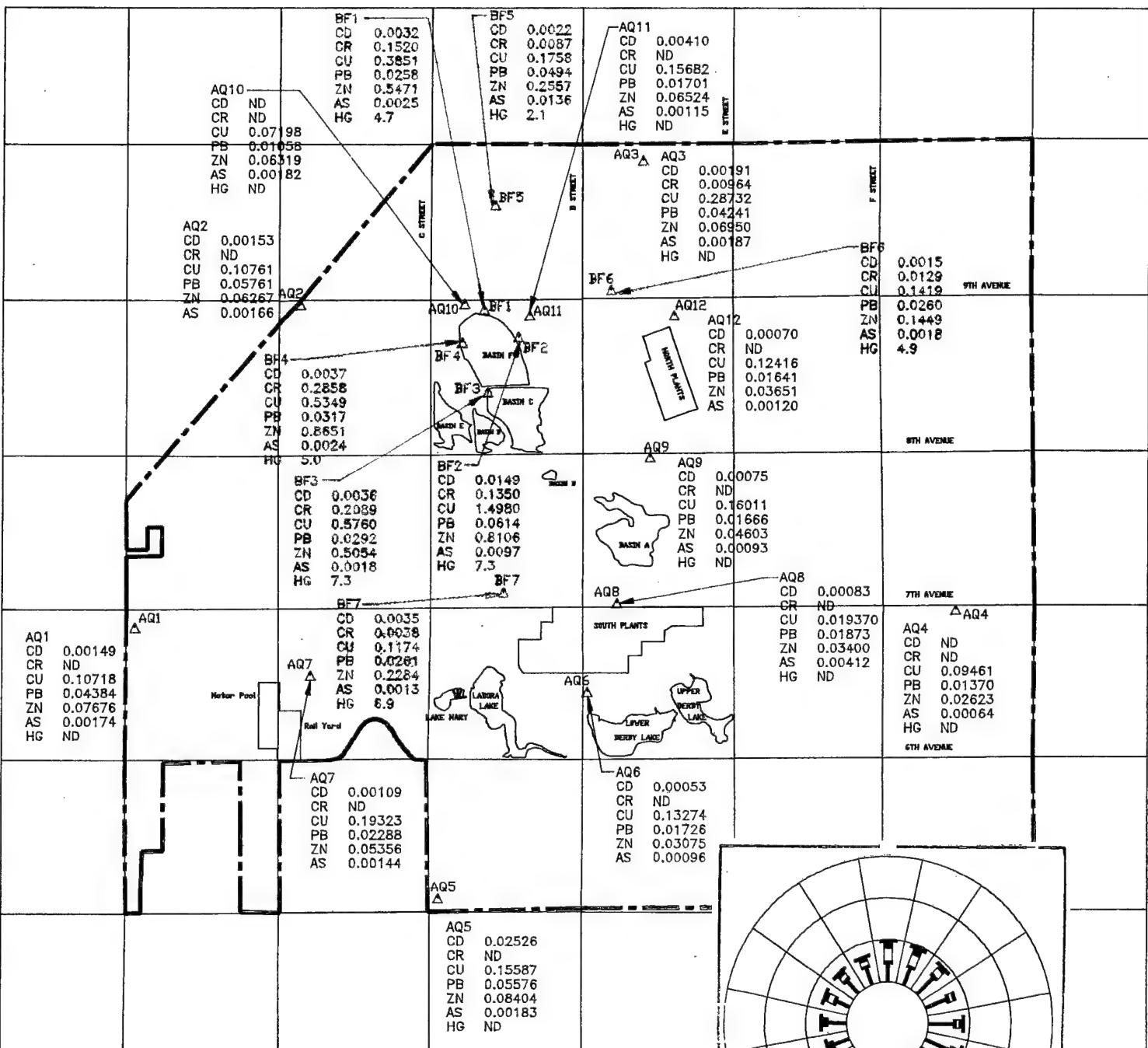
PROJECT NO:

CHKD BY : . DATE : .

22787E

FIG. NO :

4.4-13



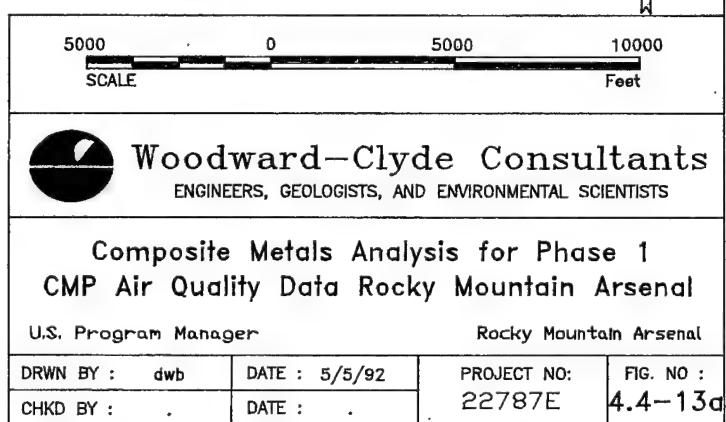
LEGEND

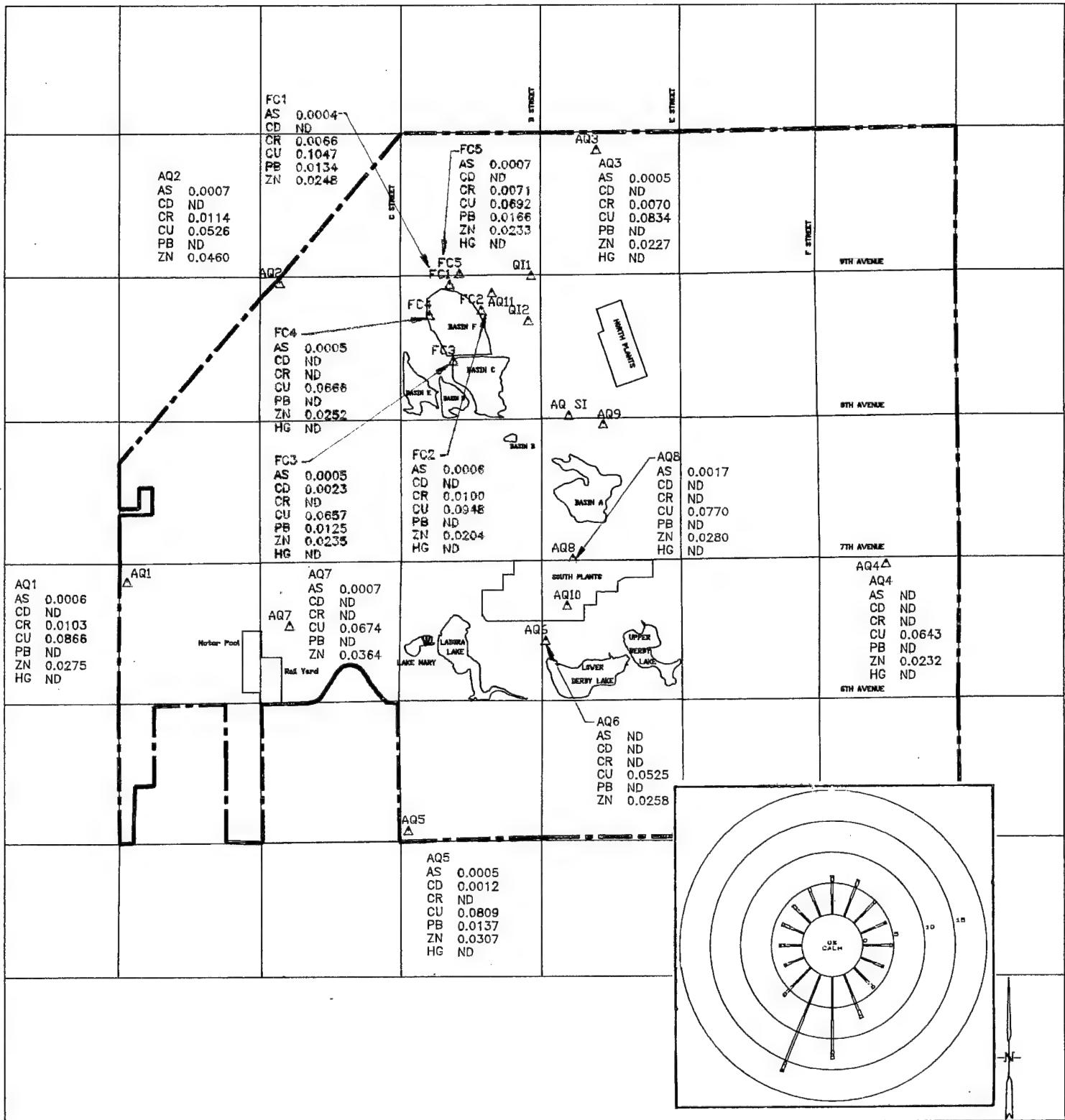
BF3 BASIN F Monitoring Location

AQ1 ▲ Comprehensive Monitoring Location

AS	=	Arsenic
CD	=	Cadmium
CR	=	Chromium
CU	=	Copper
PB	=	Lead
ZN	=	Zinc
ND	=	Non-Detectable

24 Hour Maximum (ug/m³)





LEGEND

- FC3** △ CMP FC Sites (Formerly IRA-F)
- AQ5** △ Comprehensive Monitoring Location
- AS = Arsenic
- CD = Cadmium
- CR = Chromium
- CU = Copper
- PB = Lead
- ZN = Zinc
- HG = Mercury
- ND = Non-Detectable

Annual Average (ug/m³)

RMA4414A

5000 0 5000 10000
SCALE Feet



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

Composite Metals Analysis for Phase 5
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

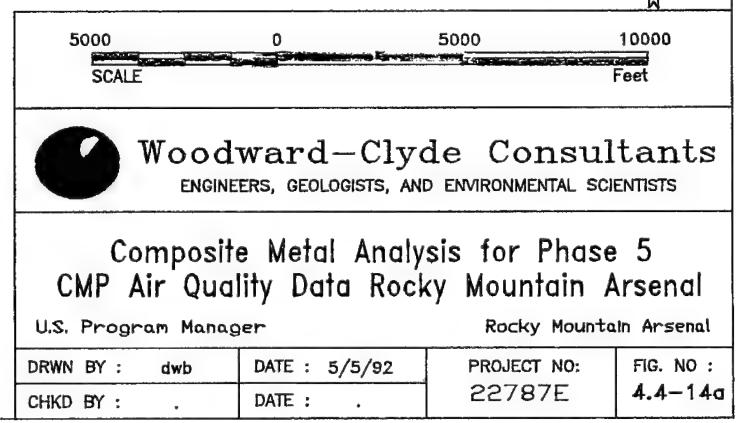
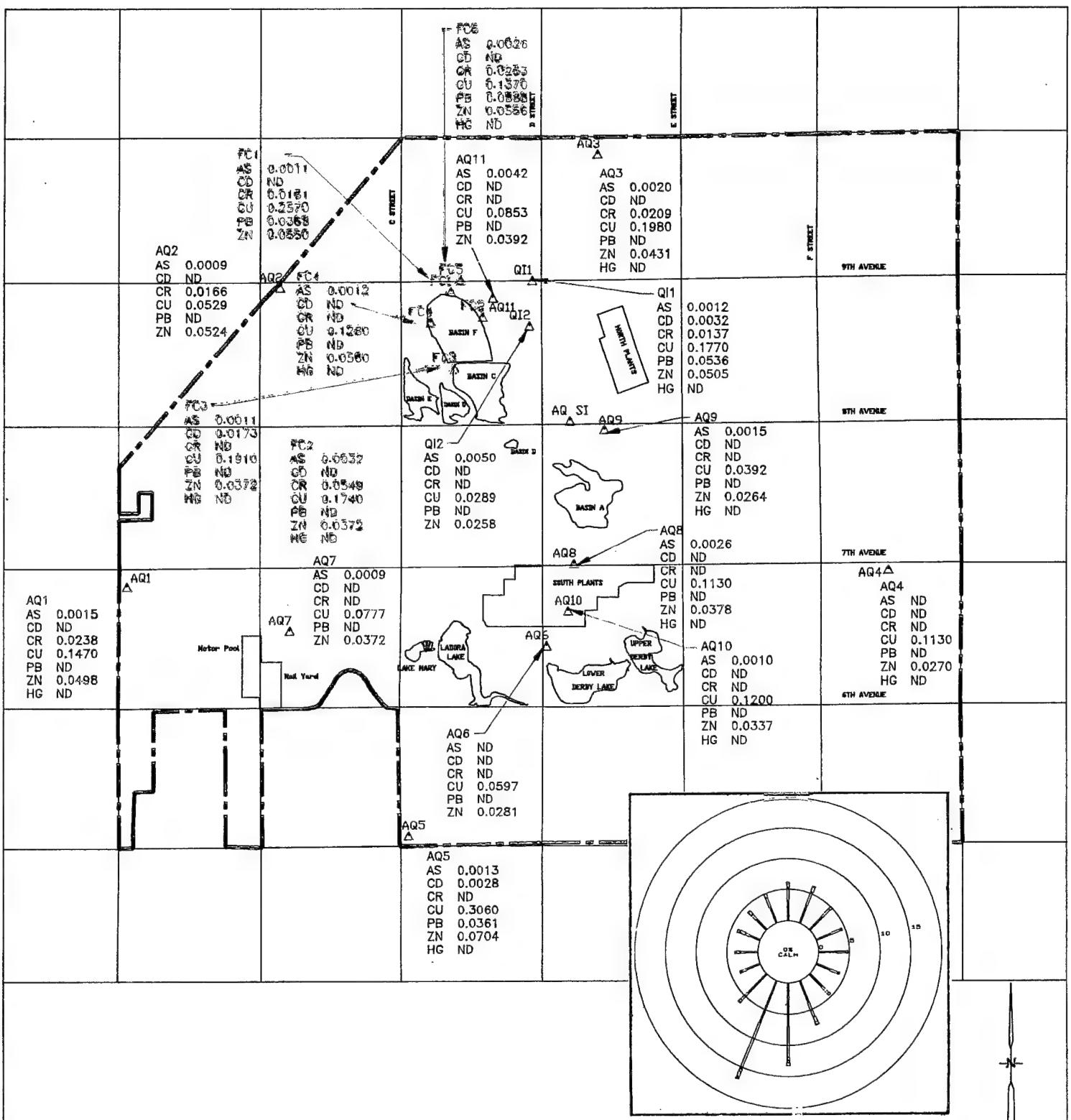
Rocky Mountain Arsenal

DRWN BY : dwb DATE : 5/5/92

PROJECT NO: 22787E FIG. NO:

4.4-14

CHKD BY : . DATE : .



4.5 ASBESTOS

Asbestos sampling was conducted at four sites for FY91 with the locations, number of samples and data recovery as described in Table 4.5-1. Sites were selected in the vicinity of asbestos sources within RMA and to maintain continuity with previous monitoring. Since asbestos detections were minimal in CMP FY88, FY89 and FY90, monitoring for FY91 reduced to quarterly sampling beginning in January, 1991. Two asbestos sampling events were performed during FY91 on March 25, 1991 and on June 29, 1991. These sample days were selected on the basis of dry soil conditions and sustained high wind speeds.

A minimum detectable level of 7 fibers/mm² (which for a target volume is equivalent to less than 0.001 fibers/ml) was established for the laboratory sample analyses. Concentrations were determined by dividing the observed counts by the fractional area observed and by the sample volume. All the samples collected during FY91 had counts below the minimum detection limit, except sites AQ6 and AQ8 for the sample period June 28, 1991. The concentrations for these two sites were 0.0005 fibers/ml and 0.0004 fibers/ml, respectively. Refer to Appendix D for asbestos results. Asbestos concentrations were generally below significant levels within RMA boundaries.

TABLE 4.5-1
SYNOPSIS OF FY91 ASBESTOS MONITORING

Station	Number of Samples	Percent of Recovery
AQ1	2	100
AQ6	2	100
AQ8	2	100
AQ12	2	100
Program Total	8	100

4.6 VOLATILE ORGANIC COMPOUNDS (VOC)

4.6.1 VOC Monitoring, Analysis, and Reporting Strategies

The CMP FY91 program monitoring strategy for VOCs differed from previous years in an effort to integrate the monitoring programs that were formerly performed separately for the CMP sites (i.e., AQxx) and the IRA-F or Basin F sites (i.e., FCxx or BFxx). VOC monitoring was conducted routinely (every 6th day) at three RMA perimeter sites, AQ2, AQ3 and AQ5, and three Basin F monitoring sites, FC1, FC2 and FC5. During the Fall quarter of 1990 (October through December), VOC monitoring only occurred at the Basin F sites. Routine VOC monitoring at all six CMP and Basin F monitoring sites occurred from January 24, 1991 to the end of FY91 (September 30, 1991). The other two Basin F sites, FC3 and FC4, monitored VOCs every sixth day until March 31, 1991 when sampling frequency was reduced to once per month. Two new sites, QI1 and QI2, designed to monitor incinerator construction area and baseline conditions prior to operation, were added to the monitoring network on March 31, 1991. These two new sites monitored VOCs every sixth day from March 31, 1991 to the end of FY91. In addition, three high event sampling episodes were conducted at four perimeter sites and four mobile sites during specified meteorological conditions as presented in Table 3.2-2. Based on the sampling strategy, data recovery for VOC monitoring is summarized in Table 4.6-1 for FY91. The cumulative data recovery for all monitoring sites for FY91 exceeded the 80 percent (i.e., 91 percent) criterion specified for air quality parameters monitored for a typical PSD program.

The CMP FY91 Program focused on: (1) routine monitoring, every sixth day, at three fixed perimeter sites and sites around Basin F to establish a long-term database and to evaluate potential Arsenal and off-Arsenal VOC impacts at the RMA boundaries; and (2) monthly and selected event sampling using interior Basin F mobile sites and two other fixed sites around Basin F to measure potential Arsenal internal source impacts. Because of the intense Basin F remedial activity during FY88, CMP VOC sampling was centered around Basin F and was supplemented by more intensive Basin F Remedial Monitoring Program sampling in order to establish a viable database for remedial assessment. During FY89 and FY90, the follow-on IRA-F Monitoring Program continued an intensive monitoring effort around Basin F as discussed in Section 4.6.3.2.

The CMP FY91 VOC program not only included both real-time and integrated air sampling of Basin F sites, but also Basin A, Basin A Neck (air stripper) and RMA perimeter sites in order to establish a broader background of VOC levels across the Arsenal and at future projected remedial locations. CMP FY91 results are discussed in Section 4.6.2. The Basin F and CMP monitoring strategies are designed to complement each other and to provide information necessary for assessing the sensitivity of ambient impacts to variations in wind flow, temperature, air dispersion characteristics, potential emission sources and other factors not directly observed. Combined Basin F and CMP VOC results will be discussed in Section 4.6.3.3 and will include FY88 through FY91 data obtained during the five phases of the remedial assessment program which are outlined in Table 4.1-1.

Seasonal VOC monitoring was initiated under the CMP FY88 program once laboratory certification methods were approved. VOC sampling continued through FY90 with little change in the basic program. In FY91, sampling frequency was increased to either every sixth day or once per month depending upon site location. As indicated in previous reports, low VOC certification ranges frequently resulted in values above the certification limit. Several adjustments were made to the air program, including lowering the sampler flow rate significantly. The termination of Basin F cleanup activities was anticipated to further reduce observed ambient concentrations. However, FY90 results continued to indicate ambient VOC concentrations above the detection limits for certain analytes. During FY91, laboratory analyses were performed by a different firm, Environmental Science and Engineering (ESE). Certain actions, with the approval of the PMRMA, were initiated and completed to refine analytical methods designed to increase the upper certified detection limit. As a result, the number of samples reported above the certified detection limits was substantially reduced.

The fact that certain target analytes were measured and analyzed above certification limits is a reflection of the certification ranges and not necessarily an implication that these values represent potential contamination risks. Extensive CMP/IRA-F monitoring program data that have been evaluated in previous CMP reports substantiates the general trend of relatively low contamination risk. Recent investigation has been conducted to assess the breakthrough trends by site location and also the effect of reducing flow rate on the frequency of occurrence of breakthrough. By reducing sampler

flow rates from approximately 200 cubic centimeters per minute (CCM) to 150 CCM, the number of analytes still exhibiting significant breakthrough decreased to four (i.e., benzene, carbon tetrachloride, chloroform and 1,1,1-trichloroethane). Methylene chloride is excluded from consideration since it is not a certified analyte under method CM04. Average percent breakthrough for these four compounds decreased from the higher to lower flow rate as presented in the following: benzene - 31.2% to 17.8%; carbon tetrachloride - 65.2% to 28.4%; chloroform - 128% to 28.6%; and 1,1,1-trichloroethane - 75.7% to 30.1%. Thus, the average percent breakthrough for these four compounds were reduced significantly and are much closer to the PMRMA criterion of 25% as an acceptable breakthrough percentage. The percentage breakthrough and the incidences of breakthrough were also observed to occur most frequently at the RMA perimeter site, AQ2, and to a lesser extent at the Basin F sites, FC1 and FC2, and the new quench incinerator site, QI2. The occurrence of breakthrough is relatively less for benzene than for the other three compounds (i.e., carbon tetrachloride, chloroform and 1,1,1-trichloroethane). Further study is being conducted on sampling with a three tube train, with either a two tenax/one tenax-charcoal or one tenax/two tenax-charcoal tube configuration, at the two sites with the most frequent occurrence of breakthrough, AQ2 and FC2, to assess if any VOCs are not being trapped by the conventional tenax/tenax-charcoal tube configuration. Results of this study will indicate if using a three sampling tube train at certain sites with highest breakthrough occurrence at a reduced flow rate will minimize the amount of VOCs not trapped by the current sampling method and whether varying sampler flow rate by site location is an effective strategy. Another consideration is whether raising analyte detection limits and, thereby, lowering the incidence and percentage of breakthrough will still result in data that can be adequately compared to applicable ambient air quality and toxic standards and/or guidelines as discussed in Section 4.6.5.

High event monitoring for VOCs was conducted mostly in the summer when elevated levels of VOCs were most likely to be prevalent. Typically, high event monitoring for VOCs was initiated when temperatures exceeded 75°F at the start of the monitoring period and winds were light. Since the wind criteria of less than 5 miles per hour (mph) was extremely difficult to predict during the summer season, especially when convective activity is at its peak during mid-afternoon hours, mobilization was triggered when winds were generally between 5 and 8 mph. Since light winds are typically variable in

direction, each high event monitoring episode focused on a particular potential emission source by surrounding the source area with several samplers.

Experience gained from previous CMP programs provided the basis for modifications and improvements to the FY91 high event program. Although, the VOC high event monitoring was initiated on very warm days with temperatures in excess of 75°F, the monitoring was generally continued through the 24-hour period to collect an integrated sample of VOCs released during warm temperatures which are allowed to stagnate during potential temperature inversion conditions. During FY91, high event monitoring was conducted at Basin F, the submerged quench incinerator construction site and the South Plants subdrain area. These events are documented in Section 4.6.2.

Data listing of CMP VOCs collected during FY91 are presented in Appendix E. In the following section, VOC sample results are summarized with available data above certified reporting limits incorporated into the analysis.

4.6.2 CMP FY91 VOC Monitoring Results

VOCs were monitored in FY91 routinely and for high event conditions. Table 4.6-2 summarizes high event sampling episodes by date, sampling duration and sampling site locations. Table 4.6-3 presents a summary of results of the sampling of target VOC analytes at both the fixed and mobile CMP site locations within RMA for FY91. Table 4.6-4 presents a summary of results of the sampling of target VOC analytes at the fixed site locations surrounding Basin F within RMA for FY91. These tables show both the annual average and 24-hour maximum concentrations of each VOC at each monitoring site. Table 4.6-4 distinguishes between data collected during the IRA-F extension (October 1990 through January 1991), designated as Phase 5, Stage 1, and during the first CMP extension and the second CMP extension that integrated both the previous CMP and IRA-F monitoring programs (January 1991 through September 1991), designated as Phase 5, Stage 2.

Six-day sampling was conducted throughout FY91, except for the period of October through December, at AQ2, AQ3 and AQ5. In addition, six-day sampling was conducted at two new sites in vicinity of the submerged quench incinerator, QI1 and QI2, from

March 31 to the end of FY91. All high event sampling episodes at CMP sites were conducted during the summer season to meet high event sampling criteria. Measured concentrations during FY91 were either comparable or lower than concentrations observed during FY88, FY89 and FY90 with the exceptions of xylenes and dicyclopentadiene. The highest maximum 24-hour concentration of xylenes at AQ2, at the northwest boundary of the RMA, was 10.079 $\mu\text{g}/\text{m}^3$ during FY91 as compared to 9.523 $\mu\text{g}/\text{m}^3$ at AQ1, at the western boundary of the RMA, during FY90. A maximum 24-hour concentration for dicyclopentadiene at mobile stations located near the South Plants, AQ01, was measured as 1.122 $\mu\text{g}/\text{m}^3$ and was also higher than concentrations measured for that analyte during FY90, but was comparable to levels measured during the earlier remediation phases. Observed concentrations for the analyte, 1,1,1-trichloroethane, increased from Phase 2, Stage 2 to Phase 4, but decreased during Phase 5 or FY91. The highest maximum 24-hour concentration decreased from 7.161 $\mu\text{g}/\text{m}^3$ at AQ5, located near the southern boundary of the RMA, during FY90 to 4.975 $\mu\text{g}/\text{m}^3$ at the same site during FY91. Elevated levels of carbon tetrachloride, chloroform and methylene chloride in vicinity of the South Plants observed during FY90 as compared to previous monitoring phases were not evident during FY91. The highest average measurements of 1,2-dichloroethenes were observed at the new quench incinerator monitoring sites, QI1 and QI2. The perimeter sites, particularly AQ1 at the western boundary of the RMA and AQ2 on the northwest boundary of the RMA, had relatively higher concentrations of 1,1,1-trichloroethane, benzene, ethylbenzene, toluene and xylenes as compared to the other sites during FY91.

Several VOC target analytes including benzene, chloroform, ethylbenzene, toluene and dimethyl disulfide, previously identified as potential emissions from Basin F, continued to be reported at lower values at the Basin F sites during FY91, consistent with the trend noted during FY90. The only exception to this trend were observed concentrations of benzene at FC1 with an average of 2.2 $\mu\text{g}/\text{m}^3$ and a maximum 24-hour average concentration of 9.1 $\mu\text{g}/\text{m}^3$ during Phase 5, Stage 1. These values were somewhat higher than observed during FY90, but still lower than levels measured during the previous remediation phases. Highest average concentrations of benzene, carbon tetrachloride, chloroform, toluene and tetrachloroethane were measured at the Basin F sites as compared to the other sites during FY91. However, most of these maximum values were

only slightly higher than observed at the other RMA sites and were well below peak values measured during the Basin F remediation period (Phases 1 and 2).

Maximum 24-hour average VOC concentrations indicated the same pattern as the long-term average concentrations; locations of maximum 24-hour VOC levels were scattered across the RMA and included sites surrounding the Basin F area, the incinerator construction area, the South Plants and the RMA perimeter sites. All maximum 24-hour VOC levels in FY91 were well below values observed during previous remediation phases.

During FY91, high event monitoring was conducted in vicinity of Basin F, the quench incinerator construction area and the South Plants subdrain area. Samples from the mobile site (Mobile E) surrounding the quench incinerator construction area were designated as AQ25, indicative of the section location of the site. Samples from the four mobile sites (Mobile E, Mobile S, Mobile SC and Mobile W) surrounding the South Plants subdrain area were grouped together and designated as AQ01, again indicative of the section location of the sites. Each high event scenario is examined individually since the distribution and magnitude of VOC concentrations vary considerably as a result of meteorological dispersion conditions and the characteristics of the primary emission source potentially contributing to observed VOC levels. These scenarios are presented in the following sections.

4.6.2.1 Basin F High Event Scenario, June 12-13, 1991

VOCs were monitored during this event at four RMA perimeter sites (AQ1, AQ3, AQ4 and AQ5) and at four sites surrounding Basin F (FC1, FC2, FC3 and FC5) from 1200, June 12, to 1200, June 13, 1991. Figure 4.6-1 presents site locations, sampling results for the selected compounds, a wind rose depicting wind flow distribution during the sampling event and the resultant dispersion pattern assuming that Basin F was the primary emission source potentially contributing to ambient VOCs. The maximum temperature on this date was 82°F., with south and south-southwesterly winds as the prevailing wind flow during this sampling event.

Assuming that the restored Basin F area was the primary emission source of VOCs potentially contributing to ambient levels, the dispersion pattern indicates greater impacts immediately surrounding Basin F and along an axis extending north of Basin F. The observed data, however, indicated highest concentrations of 1,1,1-trichloroethane, benzene, ethylbenzene and xylenes, as presented in Figure 4.6-1, and highest values of tetrachloroethane and toluene, not presented in Figure 4.6-1, at AQ1, located at the western boundary of the RMA which was downwind of metropolitan Denver under the prevailing wind flow. The highest levels of chloroform, $2.292 \mu\text{g}/\text{m}^3$, and the highest concentration of carbon tetrachloride, $1.186 \mu\text{g}/\text{m}^3$, were measured at FC5, directly north of Basin F, suggesting that ambient impacts of these VOCs were influenced by the restored Basin F area. In general, VOC concentrations were higher north of Basin F at FC1, FC2 and FC5 than at FC3, south of Basin F. However, observed VOC concentrations were below typical Basin F-related VOC concentrations reported during the active remediation periods.

4.6.2.2 Quench Incinerator Construction Area High Event Scenario, June 20, 1991

VOCs were monitored during this event at three RMA perimeter sites (AQ1, AQ3 and AQ5) and at four sites surrounding the quench incinerator construction site (QI1, FC2, QI2 and AQ25) from 1100, June 20, to 1100, June 21, 1991. Figure 4.6-2 presents site locations, sampling results for the selected compounds, a wind rose depicting wind flow distribution during the sampling event and the resultant dispersion pattern assuming that the quench incinerator construction site was the primary emission source potentially contributing to ambient VOCs. The maximum temperature on this date was 87°F., with northwest clockwise to northeast winds as the prevailing wind flow during this sampling event. However, wind flow was variable throughout the 24-hour period as evidenced by occurrences of hourly wind direction from ten of the sixteen possible wind direction sectors.

Assuming that the quench incinerator construction area was the primary emission source of VOCs potentially contributing to ambient levels, the dispersion pattern indicates greatest impacts immediately surrounding the construction area and along an axis extending southeast of the construction area. The observed data, however, indicated highest concentrations of nearly all VOC analytes at AQ1, at the western boundary of

the RMA, and to a lesser extent at AQ5, at the southern boundary of the RMA, suggesting that metropolitan Denver is the primary emission source contributor to observed VOC concentrations during this sampling event.. The highest chloroform concentration of $0.072 \mu\text{g}/\text{m}^3$ was measured at AQ3, at the northern boundary of the RMA while other observed chloroform concentrations were relatively uniform among the other sites. Concentrations of most VOCs were nearly uniform with slightly higher levels downwind at QI2 and AQ25, indicating the possibility of localized influences from the construction area such as construction equipment and vehicular activity.

4.6.2.3 South Plants Subdrain Construction High Event Scenario, June 26, 1991

VOCs were monitored during this event at four RMA perimeter sites (AQ1, AQ3, AQ4 and AQ5) and at four sites surrounding the South Plants subdrain construction area (Mobile SC, Mobile E, Mobile S and Mobile W) from 0800, June 26, to 0800, June 27, 1991. Figure 4.6-3 presents site locations, sampling results for the selected compounds, a wind rose depicting wind flow distribution during the sampling event and the resultant dispersion pattern assuming that the South Plants subdrain construction area was the primary emission source potentially contributing to ambient VOCs. The maximum temperature on this date was 83°F ., with north-northeast winds as the prevailing wind flow during this sampling event. However, wind flow was variable throughout the 24-hour period as evidenced by occurrences of hourly wind direction from nine of the sixteen possible wind direction sectors.

Assuming that the South Plants subdrain construction area was the primary emission source of VOCs potentially contributing to ambient levels, the dispersion pattern indicates greatest impacts immediately surrounding the construction area and along an axis extending east and west of the construction area, with higher concentrations occurring to the west. The observed data, however, indicated highest concentrations of nearly all VOC analytes except for chloroform, bicycloheptadiene and dicyclopentadiene divided between AQ1, at the western boundary of the RMA, and AQ5, at the southern boundary of the RMA, suggesting that metropolitan Denver is again the primary emission source contributor to most observed VOC concentrations during this sampling event. The highest chloroform concentration of $0.169 \mu\text{g}/\text{m}^3$ was measured at AQ3, at the northern boundary of the RMA while relatively higher values of chloroform occurred

at the mobile sites. The peak measurement of bicycloheptadiene was 0.226 $\mu\text{g}/\text{m}^3$ at AQ10 while the highest measurement of dicyclopentadiene was 1.122 $\mu\text{g}/\text{m}^3$ at the Mobile South (S) site. Thus, observed concentrations of bicycloheptadiene and dicyclopentadiene apparently resulted from South Plants activities. In general, most of the VOC concentrations were uniform within immediate vicinity of the South Plants area with slightly elevated values at the Mobile West (W) site, possibly an indication of localized influences within the construction area.

4.6.3 Basin F VOC Impacts

A comprehensive evaluation of ambient impacts from the Basin F cleanup operations, other remedial activities and during recent periods of relative inactivity is performed by considering all CMP, Basin F Remedial Monitoring Program, IRA-F and the integrated CMP/IRA-F program data collected during the remedial and post-remedial periods. Some comparisons of data from different monitoring periods have been presented in previous sections; however, this section will provide a more detailed comparative analysis.

4.6.3.1 CMP Data

CMP FY90 VOC results were discussed in the previous section. Table 4.6-5 incorporates CMP FY88, FY89, FY90 and FY91 data and stratifies results for the Phase 1 and Phase 2 remediation periods and the Phase 3, Phase 4 and Phase 5 post-remedial periods. The VOC CMP data show variations across the Arsenal during the separate phases of evaluation. These variations can be a function of meteorological conditions, seasonal impacts, RMA source characteristics and the presence of background sources. Except for the instances discussed in Section 4.6.2, VOC target analyte concentration variations outside the immediate vicinity of Basin F remediation activities were generally at comparable levels during each phase of the 43 month monitoring period. Variations were also apparent at CMP Basin F monitoring locations. Several target compounds that were previously identified in the FY88 report as potential contaminants emitted from the Basin F source and associated remediation activity were noticeably reduced during the FY90 Phase 4 period and remained at similar levels during the FY91 Phase 5 period. Such contaminants include benzene, chloroform,

ethylbenzene, toluene and dimethyl disulfide. Basin F stations previously shown as CMP/BF1 through CMP/BF4 in Phases 1, 2 and 3 were grouped as AQ23 and AQ26 in the Phase 4 period because of the mobile nature of the FY90 monitoring program. In addition, certain mobile stations used during high event sampling in FY91 were grouped as described in Section 4.6.2.

The emphasis in the CMP has been to provide a broad pattern of baseline air quality conditions at Arsenal remediation locations, interior locations, and perimeter sites. Because of the more intense monitoring efforts under the Basin F Remedial Monitoring and IRA-F programs, the CMP effort has been designed to supplement and confirm data collected from other programs. CMP results for FY88, FY89, FY90 and FY91 have been combined with Basin F results to provide probable indication of the extent and distribution of RMA impacts on ambient air. More detailed and statistically conclusive results from the Basin F monitoring programs adjacent to the remedial operations are provided in Section 4.6.3.2. The CMP data primarily reflect the dispersal characteristics of potential Basin F contaminants outside the immediate vicinity of Basin F and impacting Arsenal perimeter areas. The decrease in potential contaminant levels with increased distance from Basin F, particularly during Basin F remedial activities, is clearly evident; however, this trend has become less pervasive during the post-remedial phases as significant decreases in VOC levels have occurred. Further detail is provided in Section 4.6.3.3.

4.6.3.2 Basin F Data

Table 4.6-6 presents average and 24-hour maximum VOC concentrations for the Basin F Remedial Monitoring Program and for the IRA-F Monitoring Program for each phase of the remedial and post-remedial activities. All Phase 1 data and Phase 2 data (Stage 1 and Stage 2) were obtained from the Basin F Remedial Monitoring Program and RIFS Odor Program and cover the period from March 22, 1988, to May 5, 1989. The Phase 3 and Phase 4 data were obtained from the IRA-F Monitoring Program and cover the post-remedial period from May 6 to September 30, 1990. The Phase 5 data were obtained from the post-remedial periods combining the IRA-F Monitoring Program during October 1990 to January 1991 and the integrated CMP and IRA-F Monitoring Program during January to September 1991. Concentrations greater than the CRL were

included in the annual and maximum summaries only when estimates of the actual values were available from the lab. Sequential data are provided in Appendix E.

Table 4.6-6 provides a detailed summary for each VOC target compound for each remediation phase at the seven Basin F and two RIFS monitoring sites. It can be seen from these data that several VOC compounds measured higher levels in the vicinity of Basin F during the Phase 1 and/or Phase 2 periods, while noticeable decreases for these same compounds were then measured in the Phase 3, Phase 4, and Phase 5 post-remedial periods. Specific VOCs observed at higher levels during the remediation period included methylene chloride, acetone, chloroform, 1,1,1-trichloroethane, carbon tetrachloride, toluene, bicycloheptadiene, dimethyl disulfide, dicyclopentadiene, chlorobenzene, xylene and 1,2-dichloroethane. Several of the higher levels during Phase 1 were the result of isolated maximum values such as for chloroform, chlorobenzene, xylene and 1,2-dichloroethane. Some of the variations in the compound levels may be from regional sources that were measured at higher levels because of specific seasonal and other meteorological influences and not necessarily because they were emitted as a result of Basin F remediation activities. For example, the highest carbon tetrachloride average values were measured during Phase 2, Stage 1 at the Arsenal eastern boundary and the off-site RIFS2 site and may have been a reflection of Commerce City industrial activity. Several VOCs measured may also have resulted from gasoline and diesel fume releases from heavy vehicle activities associated with the remediation, including 1,1,1-trichloroethane, benzene, chloroform and toluene. Also, several of these compounds were observed at high levels at the two RIFS Odor Program sites. These sites were adjacent to moderate to heavy Commerce City traffic activities, including railroad freight car movements; higher VOC levels may well have resulted from these urban sources. However, a portion of these VOCs can be assumed to have resulted from the remediation process.

Figures 4.6-4 through 4.6-8 show bar graph depictions of average concentrations of bicycloheptadiene, chloroform, dicyclopentadiene, dimethyl disulfide and toluene measured during each phase of the remediation activities and after the completion of the cleanup program. A significant decrease of these compounds was observed at the termination of the remediation program. Also noted from these data is the decrease in concentration levels (even during Phase 1) with distance from the Basin F source. This

suggests that Basin F was the principal emitter of these potential contaminants, and that the impacts were localized and decreased beyond the immediate vicinity of the remediation activities. This was confirmed by CMP monitoring results at RMA's more distant monitoring sites and at the boundaries, and will be discussed further in the next section.

As in the case of metals, another approach to assessing remedial progress for VOCs is to consider Basin F impacts that were observed on individual days during the remedial and post-remedial periods. All Basin F monitoring during the Phase 1 and Phase 2 periods was conducted for worst-case 24-hour periods based on dispersion model analysis and remedial activity. An example of the dispersion of VOCs resulting from Basin F Phase 1 remedial activities is shown in Figure 4.6-9. This figure shows VOC concentrations for August 12, 1988, with X/Q dispersion values overlaying the monitoring data for the seven Basin F monitoring sites. Again, this type of analysis identifies the potential dispersion of VOCs and other contaminants that would result from remedial actions at Basin F being the primary emission source contributor. During this sample period, the winds were variable in direction and flowed at moderate speeds. The maximum temperature was 88°F. The dispersion pattern shows a broad distribution of 24-hour Basin F impacts of dimethyl disulfide, bicycloheptadiene, and ethylbenzene to the northeast and a secondary distribution to the west through west-northwest. The VOC concentrations at upwind site BF7 were nondetectable. At the perimeter sites around Basin F, the levels were highest at site BF1 immediately downwind of the basin, and at BF2 near the site of the most intense remedial activity. At the downwind off-site BF5, levels dropped off considerably. These data support the conclusion that Basin F was a source of the reported contaminants.

Figure 4.6-10 shows the X/Q dispersion pattern and the results for a Phase 4 (post-remedial) sample period, July 27-28, 1990, selected on the basis of similar dispersion characteristics (i.e., meteorology) as August 12, 1988. Winds on this sample day were moderate and variable, but predominantly from the south. The maximum sample day winds were moderate and variable, but predominantly from the south. The maximum temperature was 80°F. There were no detectable amounts of dimethyl disulfide or bicycloheptadiene during the sample period, indicating that Basin F was not a source of these compounds on this day. The pattern of ethylbenzene shows that the concentrations

at all sites were roughly 50 percent lower than on the Phase 1 day. From comparison of these typical summer day results, it appears that while Basin F was a likely source of VOCs during the remediation effort, it was not nearly as influential a source during the post-remediation period.

4.6.3.3 Combined CMP and Basin F Data Analysis

Individual CMP and Basin F VOC monitoring data for the phases of the remedial and post-remedial monitoring programs were shown in Tables 4.6-5 and 4.6-6. Figures 4.6-11 through 4.6-12A provide illustrations of all available average and 24-hour maximum VOC data across the Arsenal complex for the Phase 1 remedial period and the Phase 5 post-remedial period. CMP data collected in the vicinity of Basin F are shown next to the Basin F data on these figures and printed in red. Samples were collected at the Basin F sites under both the IRA-F and the integrated CMP and IRA-F program in FY91; combined results of both programs are shown in Figures 4.6-12 and 4.6-12A. The wind roses reflecting likely dispersion patterns are also shown in these figures. Examination of the VOC data indicates impacts for certain VOC compounds including benzene, chloroform, ethylbenzene, toluene, and dimethyl disulfide adjacent and immediately downstream from Basin F during the Phase 1 period. Further downwind, impacts were minimal and representative of the regional emission sources affecting the Arsenal. By examining VOC data likely to originate from Basin F, these VOC impacts were evidently localized close to remediation activities. During the post-remedial Phase 5 period (Figures 4.6-12 and 4.6-12A), the impacts for most of the VOC component remained at similar levels as in Phase 4, and concentrations at all CMP and IRA-F monitoring sites appeared to be at normal baseline levels. Table 4.6-7 summarizes maximum average and maximum 24-hour concentrations for the CMP, Basin F, and IRA-F programs throughout the 43-month CMP monitoring period, including data for RIFS Sites 1 and 2 (see FY89 Air Quality Data Assessment Report). RIFS Site 2 was located approximately one-half mile north of the Arsenal's northern boundary.

4.6.4 Additional VOC Monitoring Considerations

4.6.4.1 Seasonal VOC Impacts

The CMP VOC high event program was designed to select monitoring periods when maximum emissions were anticipated in the vicinity of potential RMA emission source locations. The criteria of warm temperatures and light winds appeared to be the most favorable conditions for the release of volatile organic compounds from soil surrounding potentially contaminated areas, especially during remediation activities. This anticipated correlation between meteorological conditions and observed ambient VOC concentrations was most evident during the intense Basin F cleanup effort, when CMP monitors immediately downwind from Basin F measured peak levels of several VOC analytes that appeared to be related to remediation or construction activities. These compounds included 1,2-dichloroethane, bicycloheptadiene, benzene, chloroform, chlorobenzene, dicyclopentadiene, dimethyl disulfide, ethylbenzene and xylenes. During the post-remediation period, however, there was a substantial decrease in these ambient concentrations. A shift in the location of maximum values from the Basin F area to the RMA perimeter, as well as a change in the optimum period for measuring peak VOC concentrations was also evident.

Initially, summertime high event monitoring of ambient VOCs, when temperatures are warmest and VOCs are more readily released into the atmosphere, was anticipated to provide the highest VOC concentrations. Although, some of the VOC analytes were measured at relatively higher levels in the vicinity of Basin F during the summer of 1988 (Phase 1) remediation period, the general seasonal distribution of average VOC concentrations does not unequivocally exhibit maximum average values during the summer season only. Table 4.6-8 shows the average seasonal distribution of VOCs from the combined 43-month CMP period (four spring and summer seasons, two fall seasons and three winter seasons). The summer periods include high events for each of the four years that VOC data were collected. Highest concentrations of some of the individual VOC analytes were measured in the fall and, to a lesser extent, winter (i.e., 1,1,1-trichloroethane, benzene, carbon tetrachloride, ethylbenzene, toluene and xylenes). This result suggests that urban air emissions transporting into the RMA from metropolitan Denver may have been the dominant influence, especially during the fall

and winter when temperature inversion and brown cloud conditions exist. Some of the other VOC analytes exhibited site-specific maxima during the spring and summer seasons (i.e., methylene chloride at stations AQ2 and AQ5), but general seasonal trends considering all CMP sites do not show a consistent spring and summer average maxima as compared to fall and winter average concentrations. VOC analytes associated with Basin F remediation activities such as methylene chloride, chloroform, 1,2-dichloroethane, bicycloheptadiene and toluene recorded highest short-term concentrations during the summer season of the Basin F remediation period (Phase 1); however, averaging these values with seasonal average concentrations from the other remedial and post-remedial phases produced overall seasonal average concentrations, based on four years of monitoring, that did not exhibit a pronounced summer season maximum.

Optimum monitoring and analysis of VOC baseline conditions at RMA requires consideration of seasonal worst-case meteorological factors as well as identifying potential impacts from both RMA and off-RMA emission sources. An on-going comparison of VOC data collected during remediation activities and during periods of fall and winter temperature inversion episodes when emissions from metropolitan Denver are transported to RMA will be performed with the cumulative database collected through subsequent fiscal monitoring years. A presentation of urban VOC emission sources is provided in the following section.

4.6.4.2 Metropolitan Denver Area VOC Emissions

Most of the ambient VOC concentrations measured at RMA interior monitoring stations during FY89, FY90 and FY91 were below values measured at Denver metropolitan stations during various studies (See Tables 4.6-12 and 4.6-13 in the FY90 data report and Tables 4.6-14 and 4.6-15 in Section 4.6.5). Measured ambient concentrations of various VOC analytes that were elevated during remediation activities (Phases 1 and 2) decreased to typical urban background levels during the post-remedial monitoring periods, Phases 3 and 4, and have continued to occur at those levels during Phase 5 or FY91. Ambient VOC concentrations measured at the RMA monitoring sites during FY91 continued to be apparently influenced by residual emissions from Basin F and from undisturbed areas of the South Plants, Basin A and the North Plants as in previous

post-remedial monitoring periods. However, most of the differences in measured ambient VOC concentrations appeared to result from varying meteorological conditions that affected on-site transport of background emissions not located within RMA to the RMA monitoring stations.

Table 4.6-9 and Figure 4.6-13 present numerous VOC point sources identified by the Colorado Department of Health (CDH) and the Citizen Fund Studies that may potentially impact air quality monitored within RMA (CDH, 1992; Citizens Fund, 1991). Emission sources included in this list were those exceeding 10 tons per year (tpy) of VOCs and represents approximately 80 percent of all VOC emissions identified in Adams, Arapahoe and Denver counties. This list of sources included several major industries (Colorado Refining Company, Conoco Denver Refinery, Sinclair Pipeline Company, Pillow Kingdom, Wyco Pipeline Company, Continental Airlines and Gates Rubber Company) and numerous smaller industrial operations, chemical plants, paint manufacturing facilities and large gasoline service stations. In addition, there are many VOC point sources below 10 tpy in the metropolitan Denver area that include dry cleaning establishments, paint stores, automobile maintenance shops and small service stations. Background VOC emissions also originate from mobile sources including gasoline and diesel burning vehicles, construction equipment and aircraft emissions from nearby Stapleton International Airport and are likely a significant portion of the total VOCs present in the metropolitan area. Another source of VOC emissions not readily quantifiable for documentation in an emissions inventory is from feedlot facilities located north of the RMA.

Table 4.6-10 classifies releases of Denver area VOC sources by specific toxicity criteria according to health-related characteristics (Citizens Fund, 1991). The release quantities are expressed in terms of total pounds of air, water and any other release medium at a particular facility. The relative toxicity of each VOC release cannot be evaluated strictly by emissions quantity. Other factors that need to be considered include chemical reactivity in the ambient air and the relative toxicity hazard of each VOC. Metropolitan Denver VOC emission sources presented in Table 4.6-11 are classified by the number of releases into the air and specific VOC components of release. The data summaries presented in Tables 4.6-10 and 4.6-11 were prepared by the Citizens Fund from disclosures that individual companies are required to file with the EPA under Title III

of SARA and are updated versions of similar tables presented in the FY90 data report. The newest, available Citizens Fund report did not include a summary with the specific information presented in Table 4.6-11 (i.e., VOC components of release); therefore, the same sources included in the FY90 report were used with air toxic release numbers and percentages adjusted from the most recent data. Toxic release and substance classifications presented in the Citizens Fund report have not been independently validated; however, this information is presented to provide a general indication of the range of potentially toxic substances that are emitted in the metropolitan Denver area and which may potentially impact the RMA air monitoring sites.

Specific VOC releases from metropolitan Denver emission sources are likely to have contributed to observed ambient VOC concentrations at the RMA air monitoring sites. Several of the major sources are within two miles of the RMA boundary such as Scott's Liquid Gold Company, Solvent Oil and Process Company, Sinclair Pipeline Company and Continental Airlines. The number, the diversity of emissions and the geographical extent of the emission sources complicates the attribution of specific off-site emission sources to observed VOC concentrations at specific RMA monitoring sites. Generally, a number of observed maximum VOC concentrations at the RMA perimeter monitoring sites occurred concurrently with prevailing wind flow from potential off-site emission sources to the RMA monitoring sites. High event monitoring during FY91 resulted in observed ambient concentrations of certain VOC analytes that were highest at perimeter sites, AQ1, AQ3, AQ4 and AQ5. A detailed discussion of each high event monitoring episode was presented in Section 4.6.2. A summary of the monitoring results with respect to off-site VOC emission sources upwind of the RMA perimeter stations is provided in the following.

On June 12, 1991, the prevailing wind direction was from the south and south-southwest with an average wind speed of approximately 12 miles per hour during the monitoring period. Relatively high values of 1,1,1-trichloroethane ($2.112 \mu\text{g}/\text{m}^3$), benzene ($2.666 \mu\text{g}/\text{m}^3$), ethylbenzene ($0.904 \mu\text{g}/\text{m}^3$) and xylene ($4.768 \mu\text{g}/\text{m}^3$) were measured at AQ1 as compared to those observed at the interior Basin F sites or the other perimeter sites, suggesting off-site transport of these VOC analytes from emission sources located southwest of the RMA. Observed concentrations of carbon tetrachloride and chloroform

were higher at the Basin F sites, suggesting more localized sources of ambient impact of these two VOC analytes.

On June 20, 1991, the prevailing wind directions were from the northwest, north-northwest, north-northeast and east with an average wind speed of approximately 15 miles per hour during the monitoring period. Again, relatively higher values of 1,1,1-trichloroethane ($0.824 \mu\text{g}/\text{m}^3$), benzene ($1.648 \mu\text{g}/\text{m}^3$), ethylbenzene ($0.664 \mu\text{g}/\text{m}^3$) and xylene ($3.038 \mu\text{g}/\text{m}^3$) were measured at AQ1 as compared to those observed at the interior sites (i.e., QI1, QI2, FC2 and Mobile E) or the other perimeter sites. In addition, AQ1 also measured the highest carbon tetrachloride concentration ($0.341 \mu\text{g}/\text{m}^3$) of all the monitoring sites utilized during this high event episode. This result suggested that off-site transport from emission sources primarily northwest of the RMA western boundary was the main contributor to observed ambient VOC concentrations.

On June 26, 1991, the prevailing wind direction was from the north-northeast with an average wind speed of approximately 8 to 10 miles per hour. Highest concentrations of 1,1,1-trichloroethane ($2.061 \mu\text{g}/\text{m}^3$), benzene ($2.580 \mu\text{g}/\text{m}^3$), carbon tetrachloride ($0.413 \mu\text{g}/\text{m}^3$), chloroform ($0.169 \mu\text{g}/\text{m}^3$) and ethylbenzene ($1.101 \mu\text{g}/\text{m}^3$) were measured at the RMA perimeter stations. However, the maxima for these five VOC analytes during this high event episode did not occur at the same site (i.e., AQ1) as in the previous two high event episodes, but were distributed among AQ1, AQ3 and AQ5. The direction from which primary off-site emissions influenced observed VOC concentrations was not as well-defined as the previous high event episodes since VOC analyte maxima were distributed among the north, west and south RMA perimeter stations. As expected, highest concentrations of bicycloheptadiene and dicyclopentadiene were measured at the mobile stations in Section 1, suggesting that the primary emission source of these two VOC analytes was from the South Plants area.

The assessment presented in this section is intended to show that measured VOC concentrations at the RMA air monitoring stations are a result of not only on-site RMA emission sources, but also exhibit significant contributions from emission sources originating from within the metropolitan Denver area. The results of this assessment provide a frame of reference to compare ambient VOC concentrations measured within

the metropolitan area to measurements at the RMA air monitoring stations which are also affected by both continual and intermittent sources of emissions located within the RMA.

4.6.5 Summary of Results and Assessment of VOC Toxicity Levels

In order to assess the significance of measured VOC concentrations relative to health standards and guidelines, a literature search was conducted using sources of information similar to those identified in the metals assessment. This search was performed because the State of Colorado has not published air toxic regulations or promulgated standards. Promulgated state air toxics standards are not anticipated until amendments to Section 112 of the Clean Air Act are finalized in 1996. Guideline values were then compared with maximum concentrations measured for the CMP, Basin F, IRA-F and RIFS programs.

The tabulation of guideline concentrations is presented as Tables 4.6-12 and 4.6-13 for each target VOC for the remedial period (Phases 1 and 2) and the post-remedial period (Phases 3, 4 and 5). The name and chemical abstract number is presented, along with the TLV (Threshold Limit Value) and the TLV/420 concentrations. The TLV for each VOC was referenced from the most recent edition of the Threshold Limit Values handbook for 1991-1992 (ACGIH, 1991). The value of TLV/420 is used because this value is employed by many states in air toxic regulations as an annual concentration guideline "not to be exceeded". The next three columns of information are risk-based air concentrations (RBACs) derived from the Integrated Risk Information System (IRIS; USEPA on-line database) and the Health Effects Assessment Summary Tables (HEAST; USEPA, 1991). The RBACs are very conservative (health-protective) concentrations based on upper-bound estimates of carcinogenicity and toxicity and "reasonable maximum" estimates of inhalation rates ($20\text{ m}^3/\text{day}$) and exposure, consistent with exposure assumptions described in the Risk Assessment Guidance for Superfund (RAGS)(USEPA, 1989). The RBACs are based on a range of unit risk factors corresponding to 10^{-4} to 10^{-6} . A "lifetime excess cancer risk level" of 10^{-4} to 10^{-6} corresponds to an 1 in 10,000 to 1 in 1,000,000 chance of getting cancer during a lifetime of exposure. The Reference Concentrations (RfCs) are air concentrations of non-carcinogens considered "safe" for a lifetime of exposure. The RBACs are applicable

for long-term exposure. The next two columns of Tables 4.6-12 and 4.6-13 present a range of "typical" state toxic guideline values based on the latest listings of the National Air Toxics Information Clearinghouse (NATICH). These values are presented for both short-term (1 to 24 hours) and long-term (annual) averaging periods.

The next two columns show the 24-hour maximum and the average maximum values measured from either the CMP, Basin F, IRA-F or the RIFS programs. The VOC data for each phase were then compared to the appropriate guideline values. The 24-hour values were compared to the 24-hour guideline values; the maximum average values were compared to the maximum long-term guideline values.

The next two columns of Tables 4.6-12 and 4.6-13 show the percentage of the highest 24-hour maximum concentrations and the highest maximum average concentrations to the guidelines. An evaluation of these data should consider the fact that worst-case periods of sampling were also selected for comparison to the guideline values. The final columns of Tables 4.6-12 and 4.6-13 show the percentage of RMA boundary monitoring station maximum concentrations and provide a comparison to the guideline values.

A conservative approach is employed in this evaluation in order to identify potential areas of concern in the context of ongoing RMA activities. The purpose of this study is not to provide a rigorous health risk assessment, but rather to provide data for such an assessment and to evaluate remedial progress over the long-term period of continuing cleanup activities. Consequently, this report summarizes two separate databases; that certified by PMRMA methods, and that which is either above the certified range or not certified by PMRMA. Results from the Basin F program, out-of-certified range data analyses and nontarget data analyses substantially assisted in assessing remedial progress and in identifying future needs and requirements. These data, however, may not fully meet specifications of PMRMA certification. All PMRMA certified and reviewed data, which consist of the majority of the metals, VOC and OCP data included in this report, are provided in Appendixes C, E, F and G. These data meet rigorous standards for quantification of the target analytes. The remaining data must be considered as valid information to be used for supplemental analysis and interpretation.

Despite using a generalized and conservative approach for the data analyses, most concentrations remained well below available toxic guidelines and standards, especially during the post-remedial periods. In several instances where a level of possible concern was identified during the remedial periods (i.e., primarily Phase 1), the post-remedial Phase 3, 4 and 5 data show these concerns no longer exist.

A review of the CMP, Basin F, and IRA-F target analyte data results and potential toxic concerns for several pertinent compounds follows. Nontarget analyte data will be considered in Section 4.6.6.

Benzene - The highest short-term benzene level, $44.3 \mu\text{g}/\text{m}^3$, was measured on a CMP high event monitoring day, August 26, 1988, in the vicinity of BF1 (at the northern perimeter of Basin F). This was an anomalously high reading and one of the few occasions when a CMP monitor in the vicinity of Basin F measured higher levels than the Basin F program monitors. This concentration was 12 percent of the 24-hour average guideline of $358 \mu\text{g}/\text{m}^3$. Maximum 24-hour benzene concentrations ranged from $0.64 \mu\text{g}/\text{m}^3$ to $13.4 \mu\text{g}/\text{m}^3$ at other CMP and Basin F monitoring stations. The second highest 24-hour level was at AQ4 at the southeast boundary of RMA. During FY91, the highest 24-hour benzene level was $9.1 \mu\text{g}/\text{m}^3$, recorded on a routine sampling day at Station FC1.

The baseline benzene concentrations appear to be evenly distributed in the RMA vicinity, with short-term peaks occasionally reported as a result of cleanup or construction activities at Basin F. At other locations, impacts were a result of diesel emissions from trucks and other heavy equipment, both on and off the Arsenal.

The highest long-term benzene average, $10.5 \mu\text{g}/\text{m}^3$ at Station BF1-(CMP), was 29 percent of the long-term average guideline of $36 \mu\text{g}/\text{m}^3$ for toxic concern (See Table 4.6-12). This comparison is based on worst-case average concentrations, including one anomalously high measurement. The maximum Basin F long-term average was $3.97 \mu\text{g}/\text{m}^3$ during Phase 2, Stage 1 at BF1, or 11 percent of the average guideline. The highest annual average during FY91 was $2.298 \mu\text{g}/\text{m}^3$ at AQ1 and was less than 7 percent of the average long-term guideline.

Bicycloheptadiene - The highest 24-hour bicycloheptadiene concentration, $39.5 \mu\text{g}/\text{m}^3$, was measured under the Basin F monitoring program at BF2 on the northeast perimeter of Basin F. The next highest 24-hour measurement was only $18.0 \mu\text{g}/\text{m}^3$ at BF1. Bicycloheptadiene was a highly localized source in the vicinity of Basin F. The highest maximum average concentration, $9.96 \mu\text{g}/\text{m}^3$ was also measured at BF2. The Basin F monitoring program measured levels of bicycloheptadiene that decreased significantly from the Basin F perimeter, especially in the post-remediation phases. CMP measurements were all well below those at the Basin F sites. There is no available toxic guideline for bicycloheptadiene.

Methylene Chloride - The maximum 24-hour methylene chloride concentration, $434 \mu\text{g}/\text{m}^3$, was measured at BF3 during Phase 2, Stage 2. Station BF6 reported a maximum 24-hour level of $179 \mu\text{g}/\text{m}^3$ during Phase 1, and BF2 reported a maximum value of $72.8 \mu\text{g}/\text{m}^3$ during Phase 2, Stage 2. The maximum measured 24-hour concentration was 5 percent of the short-term guideline of $8705 \mu\text{g}/\text{m}^3$. During Phase 5, the 24-hour maximum methylene chloride concentration was $7.64 \mu\text{g}/\text{m}^3$ measured at FC2.

Basin F was a localized source of methylene chloride, with downwind flow in the direction of BF3 and BF6. The maximum long-term average of methylene chloride was $24.0 \mu\text{g}/\text{m}^3$ at AQ5, or 176 percent of the long-term annual guideline of $13.6 \mu\text{g}/\text{m}^3$. However, this value is an average of selected worst-case conditions and represents a conservative estimate. Methylene chloride values decreased significantly with distance from Basin F. The CMP maximum levels ranged from $0.43 \mu\text{g}/\text{m}^3$ to $60.1 \mu\text{g}/\text{m}^3$ (at AQ5). Average values ranged from $0.43 \mu\text{g}/\text{m}^3$ to $24.0 \mu\text{g}/\text{m}^3$. Average values during Phase 5 continued to decrease, ranging from 0.97 to $2.20 \mu\text{g}/\text{m}^3$ at the CMP sites, and no on-site RMA source appeared to exist during that period.

Chloroform - The maximum 24-hour chloroform concentration of $37.1 \mu\text{g}/\text{m}^3$ was measured at Station BF2 during Phase 1. The next highest 24-hour chloroform concentration, $18.5 \mu\text{g}/\text{m}^3$, was measured at BF1. The long-term maximum average concentration, $6.95 \mu\text{g}/\text{m}^3$ was also measured at BF2 during Phase 1 and was 8 percent of the average annual guideline of $84 \mu\text{g}/\text{m}^3$. Long-term average concentrations at CMP sites ranged from 0.03 to $6.01 \mu\text{g}/\text{m}^3$. The data trends suggest that localized sources of

chloroform in the vicinity of South Plants and BF2 were present. During Phases 3, 4 and 5, chloroform concentrations decreased significantly.

The maximum 24-hour chloroform concentration, $37.1 \mu\text{g}/\text{m}^3$, was 6 percent of the average guideline value of $612 \mu\text{g}/\text{m}^3$ and the maximum long-term average at BF2, $6.95 \mu\text{g}/\text{m}^3$, was 8 percent of the annual average guideline of $84 \mu\text{g}/\text{m}^3$. The TLV/420 value is $126 \mu\text{g}/\text{m}^3$, and the RBAC long-term guideline is $4 \mu\text{g}/\text{m}^3$ at a risk of 10^{-4} ; consequently, the maximum long-term concentration, $6.95 \mu\text{g}/\text{m}^3$, was 6 and 174 percent of these respective guidelines. However, long-term concentrations during the post-remedial phases are at least one order of magnitude less than the remedial phase maxima.

Dimethyl Disulfide - A 24-hour maximum dimethyl disulfide concentration of $36.7 \mu\text{g}/\text{m}^3$ was measured at BF1 during Phase 1. The next highest value $24.1 \mu\text{g}/\text{m}^3$, was measured at BF2. The maximum averages were $7.86 \mu\text{g}/\text{m}^3$, measured at BF1, and $6.69 \mu\text{g}/\text{m}^3$, measured at BF2. Both Basin F and CMP maximum and average values decreased to non-detectable after Phase 2, Stage 1.

Basin F appeared to be a localized source of dimethyl disulfide. The component drifted to the north under prevailing inversion flow, but levels also decreased significantly with distance. There were no dimethyl disulfide concentrations measured to the south of Basin F sites at CMP or Basin F monitoring stations. There are no available guideline values for dimethyl disulfide.

Ethylbenzene - A 24-hour maximum ethylbenzene concentration of $13.0 \mu\text{g}/\text{m}^3$ was measured at the CMP Station BF2 monitor during Phase 1. The second maximum 24-hour concentration of $8.97 \mu\text{g}/\text{m}^3$ was measured at the Basin F program BF4 station. The maximum long-term average value, $2.39 \mu\text{g}/\text{m}^3$, was also measured at CMP Station BF2 and was less than 1 percent of the annual average guideline of $784 \mu\text{g}/\text{m}^3$. Ethylbenzene values at other sites decreased with distance from Basin F. Measurements at the CMP boundary indicated a maximum average of $1.68 \mu\text{g}/\text{m}^3$ at AQ2 during Phase 1. An annual average ethylbenzene concentration of $0.89 \mu\text{g}/\text{m}^3$ was measured at perimeter Station AQ1 during Phase 5. This may have been influenced by metropolitan Denver air quality or other off-Arsenal sources. Basin F appeared to be

a localized source of ethylbenzene during Phases 1 and 2. However, the 24-hour maximum level, $13.0 \mu\text{g}/\text{m}^3$, was less than 1 percent of the 24-hour average guideline of $21809 \mu\text{g}/\text{m}^3$.

Toluene - A 24-hour maximum toluene concentration of $158 \mu\text{g}/\text{m}^3$ was measured at BF2 during Phase 1. Maximum 24-hour concentrations decreased to less than $10 \mu\text{g}/\text{m}^3$ at other Basin F monitoring sites by the end of Phase 2. Outlying CMP monitoring stations measured a maximum short-term toluene level of $34.4 \mu\text{g}/\text{m}^3$ at AQ1 on the western RMA boundary and $27.6 \mu\text{g}/\text{m}^3$ at AQ4 on the eastern boundary during Phase 1. CMP values were $17 \mu\text{g}/\text{m}^3$ or less during Phases 3, 4 and 5. The maximum 24-hour short-term measurement was 3 percent of the 24-hour average guideline of $4915 \mu\text{g}/\text{m}^3$. The long-term maximum average toluene concentration, $23.6 \mu\text{g}/\text{m}^3$ at BF2, was 1 percent of the annual average guideline of $3755 \mu\text{g}/\text{m}^3$. During Phase 5, average toluene concentrations ranged from 1.97 to $3.70 \mu\text{g}/\text{m}^3$ at the CMP stations which are less than the lower bound value of $10.2 \mu\text{g}/\text{m}^3$ referenced in NATICH.

The higher toluene levels in the vicinity of Basin F indicated there was a source of this compound during cleanup operations. However, higher short-term and average toluene levels at the RMA boundary stations also suggested other sources of toluene, most likely from metropolitan Denver traffic and industrial activities. Average levels of toluene were lower and more uniform during Phases 3, 4 and 5 at all Basin F and CMP sites.

Other Comparisons - Tables 4.6-12 and 4.6-13 compare toxic guidelines with CMP, Basin F and IRA-F Program maximum short-term and longer-term concentrations for 22 VOC compounds. The last four columns also provide a comparison of highest RMA boundary site concentrations and the guidelines. At the boundaries, most of the measured analyte concentrations were less than 1 percent of the various guidelines. One analyte that was above 1 percent, benzene, does not appear to be entirely associated with remediation activities, but may result from both on-Arsenal and off-Arsenal activities. Methylene chloride was previously identified as a concern because of the low annual levels established by state guidelines. Another analyte close to an average guideline value is tetrachloroethene. For tetrachloroethene, the annual guideline value is $17 \mu\text{g}/\text{m}^3$. The maximum average tetrachloroethene concentration measured was $5.29 \mu\text{g}/\text{m}^3$ at BF1 during Phase 2, Stage 2. This value is approximately 31 percent of the guideline;

however, the fraction is reduced to only 0.6 percent if the TLV/420 value, 882 $\mu\text{g}/\text{m}^3$, is used as a guideline.

The EPA conducted an air toxic study in the Denver area during the summer of 1987 and the winter of 1987-1988. This study was discussed in the CMP FY89 Contamination Assessment Report and a comparison was made between maximum VOC concentrations measured in the Denver study and those measured at RMA (RLSA, 1990). An update of the results is provided in Table 4.6-14 (last column). All VOC concentrations in FY91 were considerably less than the maximum values reported in the Denver study, with the exception of total xylene. This compound was nearly the same as maximum levels previously reported at RMA and still below the Denver study value.

Where toxic guidelines vary significantly, perhaps a more meaningful evaluation would be a comparison of the RMA-measured VOC compounds with typical urban VOC levels. Table 4.6-15 compares the CMP VOC results for FY91 to published EPA studies for both the Denver metropolitan area as well as a summary of "air toxic" results from studies across the country. CMP concentrations were generally found to be less than the concentrations reported by the EPA urban airshed studies, as stated in the FY89 Report. While the average maximum levels of chloroform, benzene, and carbon tetrachloride, identified as concerns at the RMA boundaries, and other compounds identified as potential source emissions from Basin F, were equivalent to or below Denver and other urban sources levels, the intent of this observation is not to suggest that some potentially toxic air compounds may not have been emitted from various RMA sources and remedial activities. Analysis of results, again, suggests continued monitoring of these compounds with additional emphasis placed on identifying specific RMA local sources from new remediation activities, as well as regional emission sources. Concentrations of some compounds may be the result of previous Arsenal production activities; others are typical industrial and traffic related compounds and are released throughout the Denver urban metropolitan area. Several compounds were directly related to cleanup actions including emissions from vehicles and heavy equipment. Chloroform was identified in Basin F and the South Plants on several occasions. Other compounds monitored at RMA were randomly distributed and it appears that the source was from industrial activity and vehicle traffic outside of the Arsenal. Arsenal VOC measurements

need to be evaluated quantitatively in terms of other urban sources. The CMP will continue to address this issue.

In general, compounds at RMA did not appear to present toxic health risks significantly different from the urban environment of metropolitan Denver. Organic compounds that were unique to Basin F decreased rapidly with distance from this source and were at lower levels at the RMA boundaries. Examination of Tables 4.6-12 and 4.6-13 also indicates that maximum long-term concentrations of all sampled VOC analytes were below concentrations corresponding to either a lifetime excess cancer risk level of 10^{-4} or, if non-carcinogenic, the applicable RfC.

4.6.6 VOC Nontarget Analyte Results

When a sample is analyzed for GC/MS volatile organics, only target analytes with certified concentration ranges are reported. Additional nontarget analyte peaks appearing on the chromatogram at greater than 10 percent of the internal standard area can be identified on the basis of computer matching of the spectra. These nontarget analytes are commonly called 'tentative identified compounds' or TICs. The USATHAMA data management system refers to TICs as unknowns and labels them according to their relationship with the retention time of the internal standard as follows:

$$\text{UNK No.} = \frac{\text{Retention time of unknown}}{\text{Retention time of Internal Standard}} \times 100$$

Unfortunately, unknown numbers or UNKs, do not correlate to a specific TIC identification. Using the TIC to identify a specific UNK number is also not helpful in ascertaining the importance of what was identified. Therefore, significance of the nontarget compounds cannot solely be based on the laboratory's tentative identification, UNK number, and semi-quantification of the TIC. Further, information is available through the review of sample spectra and confirmation with standard materials. This process is time-consuming, costly, and may not provide the exact identification of the unknown chromatographic peaks.

Findings from a recent laboratory study on unknown identification were presented at the 14th Annual EPA Conference on Analysis of Pollutants in the Environment. The results of the study question the reliability of TIC information. Too much emphasis is placed on the instrumentation's ability to choose and quantitate a specific identified compound. The results must be considered a 'best guess' to what might actually exist in the sample.

For the air program at the Rocky Mountain Arsenal, confusion on TICs is minimized by discussing the chemical groupings (i.e., alkanes, ketones, alkenes, etc.) rather than the specific TIC provided by the laboratory (Table 4.6-16). Each identification and the supporting raw data were reviewed by CMP QA personnel to compare the choice the laboratory selected against the computer possibilities. Many of the spectra patterns were indicative of hydrocarbon compounds, hence the choice of chemical group by the computer program and the analyst were correct. By using the chemical group, associations between the groups and the ambient air environment are more straightforward and comprehensible.

Extension of the CMP air program did not request TICs for all samples. The air program at the Arsenal started with the Basin F project in 1988. TICs were provided during the Basin F remedial action and the entire regular CMP. Most of the previously collected data had been provided by Midwest Research Institute (MRI) in Kansas City. To maintain comparable data from MRI to the laboratory employed during the follow-on CMP work, four samples from various sites during January, February and March of 1991 were selected at random to represent the most common TICs observed by Environmental Science and Engineering in Denver (ESE/Denver) laboratory.

All the TICs listed in Table 4.6-16 are some type of hydrocarbon, an organic compound group composed of carbon and hydrogen atoms. The most common release of the listed alkanes, cycloalkanes, and aromatics is from automobile exhaust. Volatile hydrocarbons containing five to ten carbons are released as 2.5 percent of the total incomplete combustion of gasoline. Alkenes are also common hydrocarbons and are often found as plant products in petroleum. The alkenes observed do not contain functional groups such as plant products and in petroleum. The alkenes observed do not contain functional groups such as chlorine and fluorine suggesting that they originated from petroleum products. Incomplete combustion of jet fuel contains carbon compounds

comprised of 11 and 12 carbons and are also released from airplanes at nearby Stapleton airport, although none of these carbon compounds were detected in these samples. One ketone was reported and appears to be related to the urban air shed from the City of Denver.

Basically, the examination of TICs and conclusions from the results in the four samples from ESE/D has not significantly changed from previous evaluations of air unknowns (see CMP Annual Reports 1988, 1989, 1990 and IRA-F 1991). The investigation into the sample TICs for the CMP extension has shown comparability with prior work and provided information on the types of chemical groups that are being seen, in addition to the target analytes.

TABLE 4.6-1
SUMMARY OF ROUTINE VOLATILE ORGANIC COMPOUND (VOC)
SAMPLING FOR FY91

Station	Samples Scheduled	No. of Samples	Percent Recovery
AQ2	42	42	100
AQ3	42	42	100
AQ5	42	40	95
FC1	61	55	90
FC1C	42	39	93
FC2	61	50	82
FC3	36	31	86
FC4	36	27	75
FC5	61	55	90
QI1	31	31	100
QI2	31	28	90
PROGRAM TOTAL	485	440	91

TABLE 4.6-2
**SYNOPSIS OF FY91 HIGH EVENT MONITORING
FOR VOLATILE ORGANIC COMPOUNDS (VOC)**

Date	Period (24 Hours)	Site Locations
June 12, 1991	1200-1200	AQ1, AQ3, AQ4, AQ5, FC1, FC1C, FC2, FC3, FC5
June 20, 1991	1100-1100	AQ1, AQ3, AQ4, AQ5, FC2, Q11, Q11C, Q12, AQ25 (Mobile E)
June 26, 1991	0800-0800	AQ1, AQ3, AQ4, AQ5, AQ10, AQ01 (Mobile E, Mobile S, Mobile SC, Mobile W)

TABLE 4.6-3
SUMMARY OF FY91 CMP VOLATILE ORGANIC COMPOUND (VOC) CONCENTRATIONS (in $\mu\text{g}/\text{m}^3$)

	111TCE	112TCE	11DCLE	12DCE	12DCLE	BCHPD	C6H6	CCL4	CH2CCL2	CHCL3	CLC6H5
AVERAGE VALUES											
AQ1	1.576	*	*	*	*	*	2.298	0.415	1.778	0.103	*
AQ2	1.334	*	*	*	0.046	0.025	*	1.540	0.497	1.973	0.299
AQ3	0.802	*	*	*	0.042	0.027	*	1.107	0.366	1.012	0.089
AQ4	0.908	*	*	*	*	*	*	0.967	0.303	--	0.042
AQ5	1.586	*	*	*	0.029	0.027	*	1.470	0.397	1.646	0.325
Q11	0.968	*	*	*	0.043	0.033	*	1.038	0.410	1.161	0.146
Q12	0.978	*	*	*	0.094	0.032	*	1.108	0.414	1.665	0.144
AQ10	1.130	*	*	*	*	*	0.226	1.358	0.288	--	90.045
AQ01	1.398	*	*	*	*	*	0.109	1.530	0.225	--	0.086
AQ25	0.420	*	*	*	*	*	*	0.677	0.278	--	0.021

* All values below CRL
 -- Not Analyzed

Legend:

111TCE	1,1,1-Trichloroethane
112TCE	1,1,2-Trichloroethane
11DCLE	1,1-Dichloroethane
12 DCE	1,2-Dichloroethanes
12DCLE	1,2-Dichloroethane
BCHPD	Bicycloheptadiene
C6H6	Benzene
CCL4	Carbon Tetrachloride
CH2CCL2	Methylene Chloride
CHCL3	Chloroform
CLC6H5	Chlorobenzene

TABLE 4.6-3
(Continued)

	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	NNDMEA	DMB12	T12DCE	TCLEE	TRCLE	XYLENE
AVERAGE VALUES											
AQ1	*	*	0.890	3.699	*	--	--	--	0.664	*	4.435
AQ2	*	*	0.519	2.366	*	--	--	--	0.630	0.043	2.457
AQ3	*	*	0.271	2.105	*	--	--	--	0.362	0.029	1.273
AQ4	*	*	0.382	2.776	*	--	--	--	0.395	*	1.684
AQ5	*	*	0.458	2.486	*	--	--	--	0.582	0.030	2.275
Q11	*	*	0.335	2.041	*	--	--	--	0.451	*	1.658
Q12	*	*	0.387	2.100	*	--	--	--	0.495	0.024	1.949
AQ10	*	*	0.517	3.582	*	--	--	--	0.706	*	2.667
QA01	0.465	*	0.479	3.642	*	--	--	--	0.665	*	2.480
AQ25	*	*	0.226	1.965	*	--	--	--	0.175	*	1.155

* All values below CRL

Legend:

DCPD	Dicyclopentadiene
DMDS	Dimethyl disulfide
ETC6H5	Ethylbenzene
MEC6H5	Toluene
MIBK	Methylisobutylketone
NNDMEA	N-Nitrosodimethylamine
DMB12	Dimethylbenzene
T12DCE	Trans-1,2-Dichloroethene
TCLEE	Tetrachloroethene
TRCLE	Trichloroethene
XYLENE	Xylene

TABLE 4.6-3
(Continued)

	111TCE	112TCE	11DCLE	12DCE	12DCLE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3	CLC6H5
24 HOUR MAXIMUM VALUES											
AQ1	2.112	*	*	*	*	*	*	2.666	0.491	2.900	0.155
AQ2	3.007	*	*	0.493	0.098	*	3.715	1.794	3.470	3.530	0.057
AQ3	2.634	*	*	0.416	0.084	*	2.750	0.897	2.470	0.281	*
AQ4	1.196	*	*	*	*	*	1.258	0.326	0.556	0.062	*
AQ5	4.975	*	*	0.224	0.093	*	3.581	0.731	3.470	0.297	*
OI1	2.900	*	*	0.352	0.184	*	3.370	1.366	2.790	0.607	0.082
OI2	2.300	*	*	1.154	0.199	*	3.430	1.291	3.470	0.596	0.092
AQ10	1.130	*	*	*	*	0.226	1.358	0.288	--	0.045	*
AQ01	1.802	*	*	*	*	0.226	1.358	0.288	--	0.045	*
AQ25	0.420	*	*	*	*	*	0.677	0.278	--	0.021	*

* All values below CRL

Legend:

111TCE	1,1,1-Trichloroethane
112TCE	1,1,2-Trichloroethane
11DCLE	1,1-Dichloroethane
12DCLE	1,2-Dichloroethane
BCHPD	Bicycloheptadiene
C6H6	Benzene
CCL4	Carbon Tetrachloride
CH2CL2	Methylene Chloride
CHCL3	Chloroform
CLC6H5	Chlorobenzene

TABLE 4.6-3
(Concluded)

	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	NNDMEA	DMB12	T12DCE	TCLEE	TRCLE	XYLENE
24-HOUR MAXIMUM VALUES											
AQ1	*	*		1.101	3.730	*	--	--	1.147	*	5.501
AQ2	*	*	2.236	3.761	*	--	--	--	1.843	0.137	10.079
AQ3	*	*	0.815	3.761	*	--	--	--	0.915	0.103	3.281
AQ4	*	*	6.386	3.267	*	--	--	--	0.395	*	1.750
AQ5	*	*	1.921	3.769	*	--	--	--	1.723	0.100	8.373
Q11	*	*	1.586	3.822	*	--	--	--	1.573	*	6.899
Q12	*	*	1.450	3.887	*	--	--	--	1.853	0.050	6.910
AQ10	*	*	0.517	3.582	*	--	--	--	0.706	*	2.667
AQ01	1.122	*	0.559	3.816	*	--	--	--	0.717	*	2.885
AQ25	*	*	0.226	1.965	*	--	--	--	0.175	*	1.155

* All values below CRL

Legend:

DCPD Dicyclopentadiene
 DMDS Dimethyl disulfide
 ETC6H5 Ethylbenzene
 MEC6H5 Toluene
 MIBK Methylisobutylketone
 NNDMEA N-Nitrosodimethylamine
 DMB12 Dimethylbenzene
 T12DCE Trans-1,2-Dichloroethene
 TCLEE Tetrachloroethene
 TRCLE Trichloroethene
 XYLENE Xylene

TABLE 4.6-4
SUMMARY OF FY91 IIR-A-F VOLATILE ORGANIC COMPOUND (VOC) CONCENTRATIONS (in $\mu\text{g}/\text{m}^3$)

	111TCE	112TCE	11DCLE	12DCE	12DCLE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3	CLC6H5
PHASE 5 - STAGE 1 AVERAGE VALUES											
FC1	1.920	*	*	*	N/A	0.070	0.020	2.200	0.600	--	0.530
FC2	1.900	*	*	*	N/A	0.080	0.050	1.700	0.570	--	0.960
FC3	2.040	*	*	*	N/A	0.070	*	1.700	0.560	--	0.300
FC4	2.200	*	*	*	N/A	0.070	*	1.810	0.580	--	0.230
FC5	1.970	*	*	*	N/A	0.070	0.030	1.840	0.570	--	0.660
PHASE 5 - STAGE 2 AVERAGE VALUES											
FC1	1.016	*	*	*	0.035	0.025	0.022	1.116	0.388	1.196	0.250
FC2	0.851	*	*	0.022	0.024	0.027	0.026	0.967	0.358	2.004	0.496
FC3	1.414	*	*	*	0.49	0.026	*	1.344	0.422	1.243	0.210
FC4	1.244	*	*	*	0.029	*	*	1.228	0.367	1.118	0.158
FC5	0.995	*	*	*	0.035	0.029	*	1.124	0.378	0.930	0.340

* All values below CRL
 -- Not a Target Analyte

Legend:

111TCE	1,1,1-Trichloroethane
112TCE	1,1,2-Trichloroethane
11DCLE	1,1-Dichloroethane
12 DCE	1,2-Dichloroethene
12DCLE	1,2-Dichloroethane
BCHPD	Bicycloheptadiene
C6H6	Benzene
CCL4	Carbon Tetrachloride
CH2CL2	Methylene Chloride
CHCL3	Chloroform
CLC6H5	Chlorobenzene

TABLE 4.6-4
(Continued)

	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	NNDMEA	DMB12	T12DCE	TCLEE	TRCLE	XYLENE
PHASE 5 - STAGE 1 AVERAGE VALUES											
FC1	*	*	*	0.710	4.930	--					0.920
FC2	*	*	*	0.700	4.820	--					0.940
FC3	*	*	*	0.740	4.970	--					0.920
FC4	*	*	*	0.860	5.570	--					1.070
FC5	*	*	*	0.670	4.950	--					0.890
PHASE 5 - STAGE 2 AVERAGE VALUES											
FC1	*	*	*	0.330	2.231	*					0.485
FC2	*	*	*	0.262	2.246	*					0.406
FC3	*	*	*	0.279	2.165	*					0.467
FC4	*	*	*	0.274	1.582	*					0.397
FC5	*	*	*	0.329	2.080	*					0.485

* All values below CRL
N/A Not a Target Analyte

Legend:
 DCPD Dicyclopentadiene
 DMDS Dimethyl disulfide
 ETC6H5 Ethylbenzene
 MEC6H5 Toluene
 MIBK Methylisobutylketone
 NNDMEA N-Nitrosodimethylamine
 DMB12 Dimethylbenzene
 T12DCE Trans-1,2-Dichloroethene
 TCLEE Tetrachloroethene
 TRCLE Trichloroethene
 XYLENE Xylene

TABLE 4.6-4
(Continued)

	111TCE	112TCE	11DCLE	12DCE	12DCLE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3	CLC6H5
PHASE 5 - STAGE 1 24-HOUR MAXIMUM VALUES											
FC1	4.720	*	*	--	0.150	0.070	9.100	0.780	--	0.780	*
FC2	5.020	*	*	--	0.160	0.180	4.180	0.700	--	0.700	*
FC3	5.810	*	*	--	0.150	*	3.840	0.710	--	0.710	*
FC4	5.620	*	*	--	0.160	*	3.770	0.710	--	0.710	*
FC5	5.250	*	*	--	0.170	0.070	3.560	0.730	--	0.730	*
PHASE 5 - STAGE 2 24-HOUR MAXIMUM VALUES											
FC1	3.280	*	*	0.327	0.097	0.046	2.864	0.821	3.470	1.086	0.061
FC2	2.918	*	0.061	0.152	0.117	0.096	3.210	1.246	7.640	2.674	0.059
FC3	3.353	*	*	0.327	0.089	*	2.773	0.848	1.170	0.742	*
FC4	3.531	*	*	0.123	*	*	2.794	0.882	1.320	0.430	*
FC5	2.643	*	*	0.507	0.107	*	2.651	1.186	1.840	2.292	0.052

* All values below CRL
-- Not a Target Analyte

Legend:

111TCE 1,1,1-Trichloroethane
 112TCE 1,1,2-Trichloroethane
 11DCLE 1,1-Dichloroethane
 12DCLE 1,2-Dichloroethane
 BCHPD Bicycloheptadiene
 C6H6 Benzene
 CCL4 Carbon Tetrachloride
 CH2CL2 Methylene Chloride
 CHCL3 Chloroform
 CLC6H5 Chlorobenzene

TABLE 4.6-4
(Concluded)

	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	TCLEE	TRCLE	XYLENE
PHASE 5 - STAGE 1 24-HOUR MAXIMUM VALUES								
FC1	*	*	1.700	9.720	--	2.190	0.150	5.110
FC2	*	*	1.940	10.700	--	2.270	0.170	5.690
FC3	*	*	1.950	10.800	--	2.100	0.180	6.060
FC4	*	*	1.990	10.600	--	2.290	0.160	5.920
FC5	*	*	1.650	9.260	--	2.040	0.170	5.000
PHASE 5 - STAGE 2 24-HOUR MAXIMUM VALUES								
FC1	*	*	0.976	3.785	*	1.472	0.122	4.740
FC2	*	*	1.020	3.785	*	1.560	0.077	6.240
FC3	*	*	0.542	4.480	*	1.082	0.127	2.624
FC4	*	*	1.436	3.756	*	1.233	0.106	7.239
FC5	*	*	1.080	3.720	*	2.290	0.120	4.750

* All values below CRL
N/A Not a Target Analyte

Legend:
 DCPD Dicyclopentadiene
 DMDS Dimethyl disulfide
 ETC6H5 Ethylbenzene
 MEC6H5 Toluene
 MIBK Methylisobutylketone
 TCLEE Tetrachloroethene
 TRCLE Trichloroethene
 XYLENE Xylene

TABLE 4.6-5
SUMMARY OF CMP VOLATILE ORGANIC COMPOUNDS (VOC)
CONCENTRATIONS FOR PHASES 1-5 (in $\mu\text{g}/\text{m}^3$)

	111TCE	112TCE	11DCLE	12DCLE	12DCD	BCHPD	C6H6	CCL4	CH2CL2	CHCL3	CLC6H5	DBCP
AVERAGE VALUES												
Phase 1												
AQ1	0.987	*	*	-	0.053	*	2.659	0.417	1.890	0.336	0.086	*
AQ2	2.450	*	*	-	*	*	4.282	0.354	3.995	0.365	*	*
AQ3	0.875	*	*	-	0.058	0.121	2.192	0.362	0.971	0.159	*	*
AQ4	1.112	*	*	-	0.135	*	4.349	0.858	1.614	0.823	*	*
AQ5	1.840	*	*	-	*	*	2.465	0.456	3.287	0.193	*	*
AQ8	0.378	*	*	-	*	*	2.907	0.288	0.635	0.010	*	*
AQ9	0.842	*	*	-	*	*	1.569	0.525	0.967	0.162	*	*
AQ01	0.822	*	*	-	0.044	*	1.353	0.407	1.715	1.158	0.097	*
AQ36	0.460	*	*	-	*	*	0.534	0.360	0.673	0.556	*	*
CMP/BF1	0.822	*	*	-	*	*	10.532	0.324	0.818	0.268	0.324	0.148
CMP/BF2	0.837	*	*	0.040	-	*	2.675	3.007	0.395	4.744	3.031	0.472
CMP/BF3	1.059	*	*	0.139	-	0.041	*	2.679	0.660	0.637	0.345	*
CMP/BF4	0.533	*	*	-	*	*	1.427	0.378	0.605	0.427	*	*
Phase 2 - Stage 2												
AQ1	0.702	*	*	-	0.273	*	3.350	0.461	0.563	0.032	*	*
AQ2	0.633	*	*	-	0.480	*	2.201	0.871	0.629	0.030	*	*
AQ3	0.741	*	*	-	0.408	*	0.683	0.796	0.430	0.074	*	*
AQ5	2.015	*	*	-	0.495	*	1.372	0.914	1.177	0.045	*	*

* All values below CRL

- Not a target analyte for this site during this phase

Legend:

111TCE	1,1,1-Trichloroethane	12DCLE	1,2-Dichloroethane
112TCE	1,1,2-Trichloroethane	BCHPD	Bicycloheptadiene
11DCLE	1,1-Dichloroethane	C6H6	Benzene
12DCE	1,2-Dichloroethenes	CCL4	Carbon Tetrachloride
		CLC6H5	Chlorobenzene
		DBCP	Dibromochloropropane

TABLE 4.6-5
(Continued)

	111TCE	112TCE	11DCLE	12DCLE	12DCE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3	CLC6H5	DBCP
Phase 3												
AQ1	2.214	*	*	-	0.053	*	1.132	0.338	19.853	0.069	*	*
AQ2	1.380	*	*	-	0.044	*	1.096	0.323	16.860	0.047	*	*
AQ3	1.052	*	*	-	*	*	1.013	0.346	11.812	*	*	*
AQ5	2.331	*	*	-	0.050	*	1.118	0.337	24.012	0.044	*	*
AQ6	2.863	*	*	-	0.065	*	1.516	0.485	1.985	0.170	*	*
CMP/BF2	0.858	*	*	-	*	*	0.797	0.343	9.138	0.363	*	*
CMP/BF3	1.326	*	*	-	*	*	0.767	0.294	21.641	0.058	*	*
CMP/BF4	1.445	*	*	-	*	*	0.992	0.520	8.977	0.084	*	*
CMP/BF6	1.080	*	*	-	0.041	*	0.879	0.334	15.710	0.156	*	*
AQ01	1.782	*	*	-	0.051	0.074	1.147	0.572	3.996	1.023	0.026	*
AQ36	1.929	*	*	-	*	*	1.035	0.457	1.112	0.360	*	*
Phase 4												
AQ1	2.197	*	*	-	0.054	*	3.081	0.559	5.518	0.169	*	*
AQ2	0.996	*	*	-	0.061	*	1.378	0.337	3.214	0.037	*	*
AQ3	1.801	*	*	-	0.073	*	1.548	0.493	3.620	0.180	*	*
AQ4	1.603	*	*	-	0.047	*	1.761	0.505	4.358	0.093	*	*
AQ5	3.255	*	*	-	0.080	*	2.563	0.527	4.696	0.093	*	*
AQ6	4.044	*	*	-	*	*	1.865	0.366	5.873	0.171	*	*
AQ8	3.073	*	*	-	*	*	1.081	3.307	13.225	9.653	*	*
AQ9	2.576	*	*	-	*	*	2.851	0.392	13.299	0.330	*	*
AQ10	3.066	*	*	-	0.055	*	1.413	0.388	10.573	0.226	*	*

* All values below CRL
— Not a target analyte for this site during this phase

Legend:

111TCE	1,1,1-Trichloroethane	12DCLE	1,2-Dichloroethane
112TCE	1,1,2-Trichloroethane	BCHPD	Bicycloheptadiene
11DCLE	1,1-Dichloroethane	C6H6	Benzene
12DCE	1,2-Dichloroethenes	CCL4	Carbon Tetrachloride
		DBCP	Dibromochloropropane

TABLE 4.6-5
(Continued)

	111TCE	112TCE	11DCL	12DCE	12DCLE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3	CLC6H5	DBCP
AQ01	1.514	*	*	--	0.027	0.195	1.324	0.322	2.424	0.313	0.027	*
AQ02	4.115	*	*	--	*	*	1.898	0.237	13.281	0.208	*	*
AQ23	2.305	*	*	--	0.089	*	1.415	0.585	7.578	0.584	*	*
AQ26	2.132	*	*	--	0.095	*	1.573	0.510	6.401	0.365	*	*
AQ35	1.323	*	*	--	0.097	*	1.220	0.401	1.372	0.080	*	*
AQ36	2.554	*	*	--	*	0.150	1.180	1.357	13.189	1.679	*	*
Phase 5												
AQ1	1.576	*	*	*	*	*	2.298	0.415	1.778	0.103	*	--
AQ2	1.334	*	*	*	0.046	0.025	*	1.540	0.497	1.973	0.299	0.023
AQ3	0.802	*	*	*	0.042	0.027	*	1.107	0.366	1.012	0.089	*
AQ4	0.908	*	*	*	*	*	0.967	0.303	--	0.042	*	--
AQ5	1.586	*	*	*	0.029	0.027	*	1.470	0.397	1.646	0.325	*
Q11	0.968	*	*	*	0.043	0.033	*	1.038	0.410	1.161	0.146	0.023
Q12	0.978	*	*	*	0.094	0.032	*	1.108	0.414	1.665	0.144	0.028
AQ10	1.130	*	*	*	*	*	0.226	1.358	0.288	--	0.045	*
AQ01	1.398	*	*	*	*	*	0.109	1.530	0.225	--	0.086	*
AQ25	0.420	*	*	*	*	*	0.677	0.278	--	0.021	*	--

* All values below CRL
-- Not a target analyte for this site during this phase

Legend:

111TCE	1,1,1-Trichloroethane	12DCLE	1,2-Dichloroethane
112TCE	1,1,2-Trichloroethane	BCHPD	Bicycloheptadiene
11DCL	1,1-Dichloroethane	C6H6	Benzene
12DCE	1,2-Dichloroethenes	CCLA	Carbon Tetrachloride
		CH2CL2	Methylene Chloride
		CHCL3	Chloroform
		CLC6H5	Chlorobenzene
		DBCP	Dibromochloropropane

TABLE 4.6-5
(Continued)

	DCPD	DMDS	ETC6HS	MEC6HS	MIBK	NNDMEA	12DMB	T12DCE	TCLEE	TRCLE	XYLENE
AVERAGE VALUES											
Phase 1											
AQ1	*	*	0.713	8.610	0.074	*	0.930	*	0.864	0.110	1.689
AQ2	0.574	*	1.677	11.333	*	*	2.513	*	3.349	0.090	1.890
AQ3	*	*	0.285	3.979	0.078	*	0.438	*	0.699	0.097	0.725
AQ4	*	*	*	11.640	*	*	*	*	*	*	*
AQ5	*	*	0.332	3.853	0.066	*	0.410	*	0.778	0.094	0.880
AQ8	*	*	*	0.704	*	*	*	*	*	*	*
AQ9	*	*	*	0.525	*	*	*	*	*	*	*
AQ01	*	*	0.258	2.481	0.072	*	0.253	*	0.354	0.105	0.813
AQ36	*	*	*	0.656	*	*	*	*	*	0.303	*
CMP/BF1	0.171	0.148	0.521	5.120	0.075	*	0.251	*	0.406	0.079	1.422
CMP/BF2	1.719	0.578	2.394	9.443	0.099	*	0.337	*	0.606	0.497	3.542
CMP/BF3	*	*	0.242	2.810	0.054	*	0.270	*	0.554	*	0.526
CMP/BF4	*	0.144	0.158	2.070	0.045	*	0.258	*	0.170	*	0.597
Phase 2 - Stage 2											
AQ1	*	*	0.894	9.311	*	*	1.439	*	0.817	0.091	3.759
AQ2	*	*	0.599	7.488	*	*	0.878	*	1.043	*	2.519
AQ3	*	*	0.283	6.223	*	*	0.379	*	0.407	*	0.902
AQ5	*	*	0.675	10.016	*	*	0.982	*	2.928	*	2.276
Phase 3											
AQ1	*	*	0.338	4.866	*	*	0.435	*	0.825	0.134	0.981

* All values below CRL
— Not a target analyte for this site during this phase

Legend:

DCPD	Dicyclopentodiene	NNDMEA	N-Nitrosodimethylamine
DMDS	Dimethyl Disulfide	12DMB	Dimethylbenzene
ETC6HS	Ethylbenzene	T12DCE	Trans-1,2-Dichloroethene
MIBK	Methylisobutylketone	TCLEE	Tetrachloroethylene
			XYLENE Trichloroethylene

TABLE 4.6-5
(Continued)

	DCPD	DMDS	ETC6HS	MEC6HS	MIBK	NNDMEA	12DMB	T12DCE	TCLEE	TRCLE	XYLENE
AQ2	*	*	0.208	5.532	*	*	0.304	*	0.508	0.089	0.692
AQ3	*	*	0.132	1.006	*	*	0.136	*	0.562	*	0.409
AQ5	*	*	0.364	5.306	*	*	0.428	*	1.906	*	0.929
AQ6	*	*	0.233	2.505	0.475	*	0.360	*	0.482	*	0.869
CMP/BF2	*	*	0.193	2.852	*	*	0.249	*	0.360	*	0.715
CMP/BF3	*	*	0.218	2.929	*	*	0.248	*	0.354	*	0.170
CMP/BF4	*	*	0.252	3.901	0.089	*	0.338	*	0.988	0.115	0.970
CMP/BF6	*	*	0.166	2.316	*	*	0.152	*	1.137	0.610	0.538
AQ01	*	*	0.165	2.060	0.079	*	0.214	*	0.286	0.030	0.576
AQ36	*	*	0.165	1.976	0.173	*	0.211	*	0.768	0.123	0.561
Phase 4											
AQ1	*	*	1.382	9.228	0.257	*	1.818	*	1.658	0.141	3.881
AQ2	*	*	0.438	5.469	*	*	0.485	*	1.293	*	1.288
AQ3	*	*	0.627	4.459	0.103	*	0.813	*	0.918	0.078	2.544
AQ4	*	*	0.652	5.969	0.078	*	0.851	*	0.718	0.054	1.804
AQ5	*	*	1.011	8.109	0.173	*	1.344	*	2.389	0.093	2.955
AQ6	*	*	0.222	5.553	0.160	*	0.271	*	0.656	0.138	0.872
AQ8	*	*	0.450	11.254	*	*	0.499	*	0.665	0.199	3.533
AQ9	*	*	0.385	5.659	*	*	0.502	*	0.669	0.140	1.777
AQ10	*	*	0.313	5.321	0.201	*	0.352	*	0.662	0.098	1.009
AQ01	0.053	*	0.417	9.162	0.114	*	0.604	*	1.166	0.055	1.484
AQ02	*	*	0.452	5.651	0.251	*	0.501	*	1.336	0.124	1.331

* All values below CRL
-- Not a target analyte for this site during this phase

Legend:

DCPD	Dicyclopentadiene	N-Nitrosodimethylamine	TRCLE	Trichloroethene
DMDS	Dimethyl Disulfide	Dimethylbenzene	XYLENE	Xylene
ETC6HS	Ethybenzene	Trans-1,2-Dichloroethene		
MIBK	Methylisobutylketone	Tetrachloroethene		

TABLE 4.6-5
(Continued)

	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	NNDMEA	12DMB	T12DCE	TCLEE	TRCLE	XYLENE
AQ23	*	*	0.371	7.036	*	*	0.496	*	0.664	0.165	1.103
AQ26	*	*	0.311	5.340	*	*	0.553	*	0.869	0.064	1.246
AQ35	*	*	0.451	3.490	*	*	0.518	*	0.676	*	1.374
AQ36	*	*	0.411	8.394	*	*	0.745	*	0.663	0.336	2.850
Phase 5											
AQ1	*	*	0.890	3.699	*	-	-	-	0.664	*	4.435
AQ2	*	*	0.519	2.366	*	-	-	-	0.630	0.043	2.547
AQ3	*	*	0.271	2.105	*	-	-	-	0.362	0.029	1.273
AQ4	*	*	0.382	2.776	*	-	-	-	0.395	*	1.684
AQ5	*	*	0.458	2.486	*	-	-	-	0.582	0.030	2.275
Q11	*	*	0.335	2.041	*	-	-	-	0.451	*	1.650
Q12	*	*	0.387	2.100	*	-	-	-	0.495	0.024	1.949
AQ10	*	*	0.517	3.582	*	-	-	-	0.706	*	2.667
AQ01	0.465	*	0.479	3.642	*	-	-	-	0.665	*	2.480
AQ25	*	*	0.226	1.965	*	-	-	-	0.175	*	1.155

* All values below CRL
-- Not a target analyte for this site during this phase

Legend:

DCPD	Dicyclopentodiene	NNDMEA	N-Nitrosodimethylamine
DMDS	Dimethyl Disulfide	12DMB	Dimethylbenzene
ETC6H5	Ethylbenzene	T12DCE	Trans-1,2-Dichloroethene
MIBK	Methylisobutylketone	TCLEE	Tetrachloroethylene

TABLE 4.6-5
(Continued)

	111TCE	112TCE	111DCLE	12DCE	12DCLE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3	CLC6H5	DBCP
MAXIMUM VALUES												
Phase 1												
AQ1	3.022	*	*	-	0.148	*	4.646	0.697	5.527	1.546	0.230	*
AQ2	2.450	*	*	-	*	*	4.282	0.354	3.995	0.365	*	*
AQ3	1.450	*	*	-	0.175	0.394	3.715	0.496	1.513	0.310	*	*
AQ4	2.964	*	*	-	0.358	*	13.376	2.277	3.330	2.901	*	*
AQ5	5.264	*	*	-	*	*	4.392	0.687	7.788	0.503	*	*
AQ8	0.547	*	*	-	*	*	4.426	0.457	0.753	11.762	*	*
AQ9	1.081	*	*	-	*	*	1.821	0.614	1.504	0.169	*	*
AQ01	1.703	*	*	-	0.062	*	1.795	0.658	5.686	4.649	0.333	*
AQ36	0.753	*	*	-	*	*	0.637	0.626	0.870	0.802	*	*
CMP/BFI	1.610	*	*	-	*	*	44.293	0.516	2.436	0.506	1.415	0.414
CMP/BF2	1.076	*	0.062	-	*	12.649	7.370	0.621	22.840	14.520	2.527	17.039
CMP/BF3	1.595	*	0.271	-	0.054	*	4.635	1.123	0.981	0.625	*	*
CMP/BF4	0.937	*	*	-	*	*	2.332	0.674	1.083	0.708	*	*
Phase 2 - Stage 2												
AQ1	0.702	*	*	-	0.273	*	3.350	0.461	0.563	0.032	*	*
AQ2	0.633	*	*	-	0.480	*	2.201	0.871	0.629	0.030	*	*
AQ3	0.741	*	*	-	0.408	*	0.663	0.796	0.430	0.074	*	*
AQ5	2.015	*	*	-	0.495	*	1.372	0.914	1.177	0.045	*	*
Phase 3												
AQ1	3.238	*	*	-	0.066	*	1.351	0.409	55.740	0.114	*	*

* All values below CRL

— Not a target analyte for this site during this phase

Legend:

111TCE	1,1,1-Trichloroethane	CH2CL2	1,2-Dichloroethane
112TCE	1,1,2-Trichloroethane	BCHPD	Bicycloheptadiene
11DCLE	1,1-Dichloroethane	C6H6	Benzene
12DCE	1,2-Dichloroethenes	CLC6H5	Chlorobenzene
		CCl4	Dibromochloropropane

TABLE 4.6-5
(Continued)

	111TCE	112TCE	111DCLE	12DCE	12DCLE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3	CLC6HS	DBCP
AQ2	1.682	*	*	-	0.048	*	1.279	0.430	47.376	0.048	*	*
AQ3	1.095	*	*	-	*	*	1.251	0.445	34.008	*	*	*
AQ5	3.104	*	*	-	0.056	*	1.230	0.488	60.102	0.049	*	*
AQ6	2.863	*	*	-	0.065	*	1.516	0.485	1.985	0.170	*	*
CMP/BF2	1.151	*	*	-	*	*	1.112	0.403	14.205	0.981	*	*
CMP/BF3	1.907	*	*	-	*	*	0.932	0.373	38.977	0.096	*	*
CMP/BF4	1.887	*	*	-	*	*	1.304	1.050	16.664	0.143	*	*
CMP/BF6	1.246	*	*	-	0.047	*	1.124	0.436	41.716	0.292	*	*
AQ01	3.552	*	*	-	0.201	0.468	2.396	1.164	18.476	3.931	0.082	*
AQ36	2.019	*	*	-	*	*	1.127	0.486	1.234	0.466	*	*
Phase 4												
AQ1	5.020	*	*	-	0.118	*	4.751	1.147	19.809	0.478	*	*
AQ2	0.996	*	*	-	0.061	*	1.378	0.337	3.214	0.037	*	*
AQ3	3.963	*	*	-	0.155	*	2.900	0.993	13.243	0.444	*	*
AQ4	3.521	*	*	-	0.090	*	4.640	0.996	13.960	0.294	*	*
AQ5	7.161	*	*	-	0.178	*	7.548	1.169	13.262	0.214	*	*
AQ6	4.044	*	*	-	*	*	1.865	0.366	5.873	0.171	*	*
AQ8	3.073	*	*	-	*	1.081	3.307	0.390	13.225	9.653	*	*
AQ9	2.576	*	*	-	*	*	2.851	0.392	13.299	0.330	*	*
AQ10	4.610	*	*	-	0.095	*	1.890	0.390	19.837	0.285	*	*
AQ01	4.571	*	*	-	0.052	0.541	1.874	0.397	13.114	0.698	0.046	*
AQ02	4.115	*	*	-	*	*	1.898	0.337	13.281	0.208	*	*

* All values below CRL

- Not a target analyte for this site during this phase

Legend:

111TCE	1,1,1-Trichloroethane	12DCLE	1,2-Dichloroethane
112TCE	1,1,2-Trichloroethane	BCHPD	Bicycloheptadiene
11DCLE	1,1-Dichloroethane	C6H6	Benzene
12DCE	1,2-Dichloroethenes	CCl4	Carbon Tetrachloride
		CH2CL2	Methylene Chloride
		CHCL3	Chloroform
		CLC6HS	Chlorobenzene
		DBCP	Dibromochloropropane

TABLE 4.6-5
(Continued)

	111TCE	112TCE	111DCLC	12DCE	12DCLE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3	CLC6H5	DBCP
AQ23	3.591	*	*	-	0.163	*	1.419	0.781	13.169	0.967	*	*
AQ26	4.616	*	*	-	0.168	*	3.761	0.781	13.243	0.486	*	*
AQ35	1.562	*	*	-	0.102	*	1.441	0.404	1.399	0.083	*	*
AQ36	2.576	*	*	-	*	0.267	1.425	1.929	13.299	2.386	*	*
Phase 5												
AQ1	2.112	*	*	*	*	*	2.666	0.491	2.900	0.155	*	-
AQ2	3.007	*	*	*	0.493	0.098	*	3.715	1.794	3.470	3.530	0.057
AQ3	2.634	*	*	*	0.416	0.084	*	2.750	0.897	2.470	0.281	*
AQ4	1.196	*	*	*	*	*	1.258	0.326	0.556	0.062	*	-
AQ5	4.975	*	*	*	0.224	0.093	*	3.581	0.731	3.470	0.297	*
Q11	2.900	*	*	*	0.352	0.184	*	3.370	1.366	2.790	0.607	0.082
Q12	2.300	*	*	*	1.154	0.199	*	3.430	1.291	3.470	0.596	0.092
AQ10	1.130	*	*	*	*	*	0.226	1.358	0.288	-	0.045	*
AQ01	1.802	*	*	*	*	*	0.127	1.838	0.358	-	0.151	*
AQ25	0.420	*	*	*	*	*	0.677	0.278	-	0.021	*	-

* All values below CRL
- Not a target analyte for this site during this phase

Legend:

111TCE	1,1,1-Trichloroethane	12DCLE	1,2-Dichloroethane
112TCE	1,1,2-Trichloroethane	BCHPD	Bicycloheptadiene
11DCLC	1,1-Dichloroethane	C6H6	Benzene
12DCE	1,2-Dichloroethenes	CCl4	Carbon Tetrachloride
			DBCP Dibromochloropropane

TABLE 4.6-5
(Continued)

	DCPD	DMDS	ETC6HS	MEC6HS	MIBK	NNDMEA	12DMB	T12DCE	TCLEE	TRCLE	XYLENE
MAXIMUM VALUES											
Phase 1											
AQ1	*	*	2.656	34.438	0.152	*	4.418	*	4.924	0.262	4.854
AQ2	0.574	*	1.677	11.333	*	*	2.513	*	3.349	0.090	1.890
AQ3	*	*	0.801	8.619	0.141	*	1.850	*	1.972	0.310	1.515
AQ4	*	*	*	27.551	*	*	*	*	*	*	*
AQ5	*	*	0.954	8.260	0.243	*	1.563	*	2.929	0.169	3.069
AQ8	*	*	*	1.105	*	*	*	*	*	*	*
AQ9	*	*	*	0.814	*	*	*	*	*	*	*
AQ01	*	*	0.723	6.000	0.120	*	0.647	*	0.762	0.182	2.228
AQ36	*	*	*	1.071	*	*	*	*	*	0.510	*
CMP/BF1	0.430	0.347	2.000	10.366	0.219	*	0.541	*	0.851	0.104	6.031
CMP/BF2	5.628	1.896	13.041	23.525	0.326	*	0.628	*	1.049	2.632	16.240
CMP/BF3	*	*	0.350	4.672	0.065	*	0.435	*	0.906	*	0.857
CMP/BF4	*	0.261	0.238	2.921	0.049	*	0.382	*	0.212	*	0.887
Phase 2 - Stage 2											
AQ1	*	*	0.894	9.311	*	*	1.439	*	0.817	0.091	3.759
AQ2	*	*	0.599	7.488	*	*	0.878	*	1.043	*	2.519
AQ3	*	*	0.283	6.223	*	*	0.379	*	0.407	*	0.902
AQ5	*	*	0.675	10.016	*	*	0.982	*	2.928	*	2.276
Phase 3											
AQ1	*	*	0.772	9.317	*	*	0.992	*	1.041	0.238	2.327

* All values below CRL

-- Not a target analyte for this site during this phase

Legend:

DCPD	Dicyclopentadiene	N-Nitrosodimethylamine	TRCLE	Trichloroethene
DMDS	Dimethyl Disulfide	12DMB	XYLENE	Xylene
ETC6HS	Ethylbenzene	T12DCE	Trans-1,2-Dichloroethene	
MIBK	Methylisobutylketone	TCLEE	Tetrachloroethene	

TABLE 4.6-5
(Continued)

	DCPD	DMDS	ETC6HS	MEC6HS	MIBK	NNDMEA	12DMB	T12DCE	TCLEE	TRCLE	XYLENE
AQ2	*	*	0.309	10.157	*	*	0.397	*	1.257	0.107	0.897
AQ3	*	*	0.202	1.556	*	*	0.274	*	1.354	*	0.630
AQ5	*	*	0.696	7.672	*	*	0.786	*	3.022	*	1.873
AQ6	*	*	0.233	2.505	0.475	*	0.300	*	0.482	*	0.869
CMP/BF2	*	*	0.448	4.756	*	*	0.641	*	0.669	*	1.701
CMP/BF3	*	*	0.366	6.284	*	*	0.495	*	0.619	*	1.315
CMP/BF4	*	*	0.533	7.216	0.229	*	0.788	*	2.221	0.181	2.091
CMP/BF6	*	*	0.299	3.959	*	*	0.331	*	2.406	1.436	1.050
AQ01	*	*	0.489	3.502	0.603	*	0.487	*	0.793	0.111	1.319
AQ36	*	*	0.168	2.043	0.333	*	0.212	*	0.929	0.139	0.573
Phase 4											
AQ1	*	*	5.294	16.881	1.045	*	5.870	*	4.627	0.295	9.523
AQ2	*	*	0.438	5.469	*	*	0.485	*	1.293	*	1.288
AQ3	*	*	3.086	11.254	0.449	*	3.519	*	2.931	0.195	9.036
AQ4	*	*	2.962	11.479	0.546	*	3.431	*	2.286	0.148	5.205
AQ5	*	*	3.776	16.693	0.694	*	4.934	*	5.894	0.316	8.380
AQ6	*	*	0.222	5.553	0.160	*	0.271	*	0.656	0.138	0.872
AQ8	*	*	0.450	11.254	*	*	0.499	*	0.665	0.199	3.533
AQ9	*	*	0.385	5.659	*	*	0.502	*	0.669	0.140	1.777
AQ10	*	*	0.446	5.627	0.204	*	0.494	*	0.665	0.156	1.312
AQ01	0.119	*	0.467	11.377	0.280	*	0.987	*	1.978	0.144	1.786
AQ02	*	*	0.452	5.651	0.251	*	0.501	*	1.336	0.124	1.331

* All values below CRL

-- Not a target analyte for this site during this phase

Legend:

DCPD	Dicyclopentodiene	N-Nitrosodimethylamine
DMDS	Dimethyl Disulfide	Dimethylbenzene
ETC6HS	Ethylbenzene	Trans-1,2-Dichloroethene
MIBK	Methylisobutylketone	Tetrachloroethylene
TCLEE		Xylene
T12DCE		Trichloroethylene
TRCLE		

TABLE 4.6-5
(Concluded)

	DCPD	DMDS	ETC6HS	MEC6HS	MIBK	NNDMEA	12DMB	T12DCE	TCLEE	TRCLE	XYLENE
AQ23	*	*	0.410	11.270	*	*	0.500	*	0.666	0.290	1.327
AQ26	*	*	0.448	11.270	*	*	1.000	*	1.332	0.118	2.637
AQ35	*	*	0.471	4.003	*	*	0.528	*	0.704	*	1.402
AQ36	*	*	0.418	11.129	*	*	0.987	*	0.669	0.488	4.368
Phase 5											
AQ1	*	*	1.101	3.730	*	-	-	-	1.147	*	5.501
AQ2	*	*	2.236	3.761	*	-	-	-	1.843	0.137	10.079
AQ3	*	*	0.815	3.851	*	-	-	-	0.915	0.103	3.281
AQ4	*	*	0.386	3.267	*	-	-	-	0.395	*	1.750
AQ5	*	*	1.921	3.769	*	-	-	-	1.723	0.100	8.373
OI1	*	*	1.586	3.822	*	-	-	-	1.573	*	6.899
QI2	*	*	1.450	3.887	*	-	-	-	1.853	0.050	6.910
AQ10	*	*	0.517	3.582	*	-	-	-	0.706	*	2.667
AQ01	1.122	*	0.559	3.816	*	-	-	-	0.717	*	2.885
AQ25	*	*	0.226	1.965	*	-	-	-	0.175	*	1.155

* All values below CRL
-- Not a target analyte for this site during this phase

Legend:

DCPD	Dicyclopentadiene	N-Nitrosodimethylamine	TRCLE	Trichloroethene
DMDS	Dimethyl Disulfide	12DMB	XYLENE	Xylene
ETC6HS	Ethybenzene	T12DCE	Trans-1,2-Dichloroethene	
MIBK	Methylisobutylketone	TCLEE	Tetrachloroethene	

TABLE 4.6-6
SUMMARY OF BASIN F/IRA-F/RIFS VOLATILE ORGANIC COMPOUNDS (VOC)
CONCENTRATIONS FOR PHASES 1-5 (in $\mu\text{g}/\text{m}^3$)

	ACET	C6H6	BCHPD	CCL4	11ITCE	112TCE	CHCL3	CLC6HS	CS2	DCPD	11DCLE	12DCE	12DCLE
AVERAGE VALUES													
PHASE 1 (3/22/88 - 12/12/88)													
BF1	9.02	2.45	1.82	0.65	9.44	*	2.14	0.05	0.02	1.60	*	-	0.04
BF2	9.87	3.49	9.96	0.61	8.05	*	6.95	0.12	0.03	4.53	0.02	-	0.30
BF2C	5.78	2.94	8.84	0.38	7.12	*	5.24	0.08	0.02	3.42	*	-	*
BF3	8.36	1.94	0.49	0.52	6.94	*	0.80	*	0.02	0.52	*	-	0.03
BF4	9.38	2.54	0.55	0.42	10.53	0.05	0.91	0.03	0.02	0.48	*	-	*
BF5	12.50	2.19	0.43	0.53	8.54	*	0.88	0.02	0.02	0.34	*	-	0.03
BF6	11.23	1.86	0.11	0.33	8.82	*	0.30	*	*	0.05	*	-	0.02
BF7	14.25	2.15	0.03	0.36	6.24	*	0.14	*	0.03	0.03	*	-	0.02
RIFS1	-	4.00	0.09	0.47	1.95	*	0.34	0.03	-	0.35	*	-	0.05
PHASE 2 - STAGE 1 (12/13/88 - 2/15/89)													
BF1	13.62	3.97	0.25	1.04	5.50	*	0.77	0.02	0.03	0.45	*	-	*
BF2	11.82	3.79	0.88	0.92	5.85	*	1.89	0.03	0.03	0.32	*	-	0.06
BF2C	13.33	3.85	0.12	1.11	7.93	*	0.73	*	0.04	0.08	*	-	*
BF3	9.42	3.32	0.09	0.88	5.03	*	0.48	*	*	0.18	*	-	0.02
BF4	13.55	3.78	0.13	0.75	5.22	*	0.39	*	0.05	0.21	*	-	0.03
BF5	7.93	2.45	0.47	0.97	4.18	*	0.33	*	0.06	0.06	*	-	0.02
BF6	8.37	3.24	0.06	1.23	4.73	*	0.35	*	0.05	*	*	-	0.03
BF7	8.61	3.51	0.03	1.20	5.26	*	0.35	0.03	0.31	0.04	*	-	0.02
RIFS1	-	5.89	*	1.35	2.77	*	0.31	0.04	-	*	*	-	0.24
RIFS1D	-	7.32	*	1.74	3.41	*	1.44	0.03	-	*	*	-	0.16
RIFS2	-	4.95	0.03	1.99	2.49	*	1.08	0.03	-	*	*	-	0.36

* All values below CRL.

- Not a target analyte for this site during this phase.

Legend:	ACET	Acetone	CHCl3	Chloroform	12DCLE
	C6H6	Benzene	CLC6HS	Chlorobenzene	1,2-Dichloroethane
	BCHPD	Bicycloptadiene	CS2	Carbon Disulfide	
	CCL4	Carbon Tetrachloride	DCPD	Dicyclopentadiene	
	11ITCE	1,1,1-Trichloroethane	11DCLE	1,1-Dichloroethane	
	112TCE	1,1,2-Trichloroethane	12DCE	1,2-Dichloroethenes	

TABLE 4.6-6
(Continued)

	ACET	C6H6	BCHPD	CCL4	111TCE	112TCE	CHCL3	CLC6H5	CS2	DCPD	11DCLE	12DCE	12DCLE
AVERAGE VALUES													
PHASE 2 - STAGE 2 (2/16/89 - 5/5/89)													
BF1	7.78	2.00	0.06	0.78	3.50	*	0.30	0.0	0.02	0.13	*	-	0.03
BF2	6.90	1.65	0.03	0.70	2.57	*	0.37	0.02	0.02	0.04	*	-	0.02
BF2C	20.79	1.01	0.06	0.58	3.19	0.46	0.31	*	*	*	*	-	*
BF3	6.71	1.71	0.03	0.68	2.54	*	0.18	0.02	0.02	0.03	*	-	0.03
BF4	6.36	2.15	0.04	0.67	2.42	*	0.17	*	0.02	0.03	*	-	0.02
BF5	3.71	1.19	0.02	0.51	1.89	0.19	0.15	0.03	*	*	*	-	0.02
BF6	3.98	1.41	*	0.70	2.17	*	0.18	0.03	*	*	*	-	*
BF7	6.49	1.70	0.02	0.76	3.40	*	0.13	0.03	*	*	*	-	0.02
RIFS1	-	2.10	*	0.63	1.64	*	0.11	0.03	-	*	*	-	0.04
RIFS1D	-	2.28	*	0.53	1.22	*	0.11	0.04	-	*	*	-	0.06
RIFS2	-	1.37	*	0.89	1.30	*	0.14	*	-	*	*	-	0.08
PHASE 3 (5/6/89 - 9/30/89)													
FC1	-	1.15	*	0.35	1.09	*	0.15	0.02	-	*	*	-	0.02
FC2	-	1.00	*	0.40	1.01	*	0.27	0.02	-	*	*	-	0.03
FC2D	-	1.18	*	0.42	1.11	*	0.30	0.02	-	*	*	-	0.03
BF3/FC3	-	1.07	*	0.42	1.09	*	0.11	0.02	-	*	*	-	0.03
BF4/FC4	-	1.19	*	0.40	1.16	*	0.11	0.02	-	*	*	-	0.03
BF5	-	1.06	*	0.45	0.94	*	0.10	0.03	-	*	*	-	0.03
FC5	-	0.90	*	0.37	0.95	*	0.18	0.02	-	*	*	-	0.02
BF7	-	1.15	*	0.42	1.25	*	0.09	0.03	-	*	*	-	0.02
RIFS1	-	1.28	*	0.39	1.15	*	0.12	0.03	-	*	*	-	0.03

* All values below CRL.

- Not a target analyte for this site during this phase.

Legend:	ACET	Acetone	CHCL3	Chloroform	12DCLE	1,2-Dichloroethane
	C6H6	Benzene	CLC6H5	Chlorobenzene		
	BCHPD	Bicycloheptadiene	CS2	Carbon Disulfide		
	CCL4	Carbon Tetrachloride	DCPD	Dicyclopentadiene		
	111TCE	1,1,1-Trichloroethane	11DCLE	1,1-Dichloroethane		
	112TCE	1,1,2-Trichloroethane	12DCE	1,2-Dichloroethenes		

TABLE 4.6-6
(Continued)

	ACET	C6H6	BCHPD	CCL4	111TCE	CHCL3	CLC6H5	CS2	DCPD	11DCE	12DCE	12DCLE
AVERAGE VALUES												
PHASE 4 (10/1/89 - 9/30/90)												
FC1	-	1.36	*	0.56	1.40	*	0.30	0.02	-	*	*	0.06
FC2	-	1.33	0.04	0.58	1.41	*	0.67	0.02	-	*	*	0.07
FC2D	-	1.22	0.05	0.49	1.40	*	0.69	0.02	-	*	*	0.06
FC3	-	1.43	0.02	0.60	1.46	0.02	0.20	0.02	-	*	0.01	0.07
FC4	-	1.38	*	0.60	1.52	*	0.18	0.02	-	*	*	0.06
FC5	-	1.30	0.02	0.57	1.36	*	0.36	0.02	-	*	*	0.06
PHASE 5 STAGE 1 (10/1/90 - 1/18/91)												
FC1	-	2.200	0.020	0.600	1.920	*	0.530	*	-	*	*	0.070
FC2	-	1.700	0.050	0.570	1.900	*	0.960	*	-	*	*	0.080
FC3	-	1.700	*	0.560	2.040	*	0.300	*	-	*	*	0.070
FC4	-	1.810	*	0.580	2.200	*	0.230	*	-	*	*	0.070
FC5	-	1.840	0.030	0.570	1.970	*	0.660	*	-	*	*	0.070
PHASE 5 STAGE 2 (1/24/91 - 9/30/91)												
FC1	-	1.116	0.022	0.388	1.016	*	0.250	0.024	-	*	*	0.035
FC2	-	0.967	0.026	0.358	0.851	*	0.496	0.024	-	*	0.022	0.024
FC3	-	1.344	*	0.422	1.414	*	0.210	*	-	*	*	0.049
FC4	-	1.228	*	0.367	1.244	*	0.158	*	-	*	*	0.029
FC5	-	1.124	*	0.378	0.995	*	0.340	0.024	-	*	*	0.035

* All values below CRL.

- Not a target analyte for this site during this phase.

Legend: ACET Acetone
C6H6 Benzene
BCHPD Bicycloheptadiene
CCL4 Carbon Tetrachloride
111TCE 1,1,1-Trichloroethane
112TCE 1,1,2-Trichloroethane

CHCL3 Chloroform
CLC6H5 Chlorobenzene
CS2 Carbon Disulfide
DCPD Dicyclopentadiene
11DCE 1,1-Dichloroethane
12DCE 1,2-Dichloroethane

TABLE 4.6-6
(Continued)

	DMDS	ETC6H5	HCBD	MEK	CH2CL2	MIBK	T12DCE	TCLEE	MEC6H5	TRCLE	XYLEN
AVERAGE VALUES											
PHASE 1 (3/22/88 - 12/12/88)											
BF1	7.86	1.09	--	1.17	10.48	*	*	2.12	9.34	0.26	5.61
BF2	5.34	1.58	--	0.79	7.57	*	*	5.07	20.95	0.12	8.57
BF2C	6.69	1.56	--	0.89	10.47	*	*	3.41	23.55	0.14	7.72
BF3	0.50	0.81	--	0.57	7.17	*	*	1.13	8.27	0.21	4.23
BF4	0.91	0.92	--	0.68	6.36	*	*	1.13	8.51	0.29	5.02
BF5	0.92	0.77	--	1.29	7.77	*	*	1.21	5.47	0.24	3.94
BF6	0.04	0.78	--	0.79	15.89	*	*	1.02	7.96	0.18	4.36
BF7	0.02	0.89	--	0.79	4.99	*	*	1.07	5.60	0.17	4.57
RIFS1	0.03	1.72	--	--	4.19	0.10	*	1.56	8.00	0.12	5.44
PHASE 2 - STAGE 1 (12/13/88 - 2/15/89)											
BF1	*	1.59	*	3.31	4.01	*	*	1.55	5.24	0.17	6.75
BF2	0.02	1.49	*	3.25	2.52	*	*	1.57	5.05	0.11	6.35
BF2C	*	1.28	*	3.72	4.23	*	*	1.33	5.29	0.11	5.87
BF3	*	1.45	*	3.64	3.52	*	*	1.37	4.81	0.15	6.40
BF4	*	1.94	*	3.83	3.64	*	*	1.59	5.02	0.17	8.17
BF5	*	0.85	*	2.13	2.12	*	*	0.94	3.30	0.09	3.72
BF6	*	1.02	*	3.65	1.48	*	*	1.14	3.78	0.14	3.84
BF7	*	1.19	*	3.61	3.07	*	0.02	1.20	4.05	0.17	4.45
RIFS1	*	2.00	--	--	4.42	*	*	1.86	8.21	0.17	7.49
RIFS1D	*	2.36	--	--	5.39	*	*	2.06	10.83	0.16	9.45
RIFS2	--	1.61	--	--	4.46	*	*	1.35	7.81	0.11	6.09

* All values below CRL

-- Not a target analyte for this site during this phase

Legend: DMDS ETC6H5 HCBD MEK CH2C12

Dimethyl Disulfide Ethylbenzene Hexachlorobutadiene Methyl Ethyl Ketone Methylene Chloride

MIBK T12DCE TCLEE MEC6H5 TRCLE XYLEN

Methylisobutylketone Trans-1,2-Dichloroethene Tetrachloroethene Toluene Trichloroethene Xylene

TABLE 4.6-6
(Continued)

	DMDS	ETC6HS	HCBD	MEK	CH2CL2	MIBK	T12DCE	TCLEE	MEC6HS	TRCLE	XYLEN
PHASE 2 - STAGE 2 (2/16/89 - 5/5/89)											
BF1	0.02	1.07	*	3.71	4.14	*	*	*	5.29	3.65	6.98
BF2	*	0.52	*	3.09	6.11	*	*	*	0.78	2.84	0.24
BF2C	*	0.46	*	2.57	19.01	*	*	*	0.66	2.82	0.14
BF3	*	0.58	*	3.01	23.81	*	*	*	0.78	3.19	0.08
BF4	*	0.79	*	2.96	3.23	*	*	*	0.94	3.62	0.16
BF5	*	0.41	*	2.47	1.29	*	*	*	0.61	2.45	0.07
BF6	*	0.51	*	2.97	2.81	*	*	*	0.65	2.82	0.05
BF7	*	0.61	*	3.53	2.94	*	*	*	0.85	3.52	0.04
RIFS1	*	0.72	--	--	2.38	*	*	*	0.93	6.10	0.06
RIFS1D	*	0.67	--	--	1.23	*	*	*	0.82	6.66	0.04
RIFS2	*	0.69	--	--	1.33	*	*	*	0.77	6.03	0.04
PHASE 3 (5/6/89 - 9/30/89)											
FC1	*	0.45	--	--	0.74	0.03	*	*	0.71	1.78	0.30
FC2	*	0.60	--	--	0.55	0.02	*	*	0.61	1.80	0.04
FC2D	*	0.38	--	--	0.33	0.02	*	*	0.54	2.10	0.03
BF3/FC3	*	0.42	--	--	0.73	0.03	*	*	0.55	1.65	0.04
BF4/FC4	*	0.47	--	--	0.92	0.04	*	*	0.70	2.20	0.04
BF5	*	0.36	--	--	0.31	*	*	*	0.56	1.67	0.05
FC5	*	0.41	--	--	1.17	0.04	*	*	0.55	1.85	0.44
BF7	*	0.36	--	--	0.45	0.02	*	*	0.69	1.98	0.03
RIFS1	*	0.48	--	--	0.48	*	*	*	0.70	2.26	0.04

* All values below CRL
-- Not a target analyte for this site during this phase

Legend: DMDS ETC6HS HCBD MEK CH2Cl2
Dimethyl Disulfide Ethylbenzene Hexachlorobutadiene Methyl Ethyl Ketone Methylene Chloride

MIBK T12DCE TCLEE MEC6HS TRCLE XYLEN

Methylisobutylketone Trans-1,2-Dichloroethene Tetrachloroethene Toluene Trichloroethene Xylene

TABLE 4.6-6
(Continued)

	DMDS	ETC6HS	HCBD	MEK	CH2CL2	MIBK	T12DCE	TCLEE	MEC6HS	TRCLE	XYLEN
AVERAGE VALUES											
PHASE 4 (10/1/89 - 9/30/90)											
FC1	*	1.36	--	--	0.53	0.09	*	0.77	3.92	0.07	1.65
FC2	*	1.33	--	--	0.51	0.08	*	0.92	3.71	0.05	1.66
FC2D	*	1.22	--	--	0.51	0.10	*	0.80	3.56	0.05	1.44
FC3	*	1.43	--	--	0.50	0.10	0.02	0.89	3.62	0.06	1.61
FC4	*	1.38	*	*	0.56	0.10	*	0.86	3.42	0.06	1.65
FC5	*	1.30	*	*	0.47	0.09	*	0.79	3.53	0.10	1.63
PHASE 5 STAGE 1 (10/1/90 - 1/18/91)					--	--	--	0.920	4.930	0.050	2.170
FC1	*	0.330	--	--	--	--	--	0.940	4.820	0.050	2.200
FC2	*	0.262	--	--	--	--	--	0.920	4.970	0.050	2.380
FC3	*	0.279	--	--	--	--	--	1.070	5.570	0.040	2.470
FC4	*	0.274	--	--	--	--	--	0.890	4.950	0.050	2.040
FC5	*	0.329	--	--	--	--	--	--	--	--	--
PHASE 5 STAGE 2 (1/24/91 - 9/30/91)											
FC1	*	0.330	--	--	1.196	*	--	0.485	2.231	0.032	1.627
FC2	*	0.262	--	--	2.004	*	--	0.406	2.246	0.026	1.235
FC3	*	0.279	--	--	1.243	*	--	0.467	2.165	0.042	1.316
FC4	*	0.274	--	--	1.118	*	--	0.397	1.582	0.040	1.321
FC5	*	0.329	--	--	0.930	*	--	0.485	2.080	0.035	1.632

* All values below CRL
-- Not a target analyte for this site during this phase

Legend: DMDS ETC6HS HCBD MEK CH2Cl2

Dimethyl Disulfide Ethylbenzene Hexachlorobutadiene Methyl Ethyl Ketone Methylene Chloride

MIBK T12DCE TCLEE MEC6HS TRCLE XYLEN

Methylisobutylketone Trans-1,2-Dichloroethene Tetrahydroethene Toluene Trichloroethene Xylene

TABLE 4.6-6
(Continued)

	ACET	C6H6	BCHPD	CCL4	111TCE	112TCE	CHCL3	CLC6H5	CS2	DCPD	11DCLE	12DCLE	12DCLE
24-HOUR MAXIMUM VALUES													
PHASE 1 (3/22/88 - 12/12/88)													
BF1	47.73	6.89		17.98	3.89	72.54	*	18.51	0.45	0.08	4.58	*	0.23
BF2	55.53	10.83		39.46	6.68	53.40	*	37.15	0.80	0.24	29.12	0.08	1.89
BF2C	28.58	9.22		26.19	1.60	28.58	*	31.14	0.52	0.05	8.30	*	*
BF3	81.65	5.20		2.69	4.00	62.88	*	3.11	*	0.05	6.04	*	0.24
BF4	112.12	6.52		12.25	5.61	67.00	1.12	18.03	0.39	0.03	3.74	*	*
BF5	121.38	6.82		2.64	1.19	40.48	*	5.65	0.05	0.04	2.15	*	0.15
BF6	41.93	5.74		0.50	1.17	71.11	*	1.70	*	*	0.41	*	0.09
BF7	151.22	6.47		0.13	1.41	22.06	*	0.67	*	0.14	0.14	*	0.04
RIFS1	--	9.59		0.49	0.95	4.78	*	1.33	0.12	--	3.77	*	0.25
PHASE 2 - STAGE 1 (12/13/88 - 2/15/89)													
BF1	56.24	8.87		1.77	1.93	9.45	*	3.24	1.55	0.09	3.36	*	*
BF2	42.24	7.78		6.66	2.21	17.47	*	16.41	0.06	0.12	2.48	*	0.59
BF2C	44.49	6.07		0.46	1.75	28.90	*	1.57	0.10	0.22	0.18	*	*
BF3	30.04	6.83		0.85	2.52	11.48	*	1.19	*	*	1.27	*	0.11
BF4	54.75	8.97		1.51	1.30	15.74	*	0.92	*	0.29	1.37	*	0.24
BF5	22.34	4.71		7.27	1.59	8.55	*	0.75	*	0.71	0.60	*	0.12

* All values below CRL.

-- Not a target analyte for this site during this phase.

Legend:	ACET	Acetone	CHCL3	Chloroform	12DCLE
	C6H6	Benzene	CLC6H5	Chlorobenzene	1,2-Dichloroethane
	BCHPD	Bicycloheptadiene	CS2	Carbon Disulfide	
	CCL4	Carbon Tetrachloride	DCPD	Dicyclopentadiene	
	111TCE	1,1,1-Trichloroethane	11DCLE	1,1-Dichloroethane	
	112TCE	1,1,2-Trichloroethane	12DCE	1,2-Dichloroethenes	

TABLE 4.6-6
(Continued)

	24-HOUR MAXIMUM VALUES												
	ACET	C6H6	BCHPD	CCL4	111TCE	112TCE	CHCL3	CLC6H5	CS2	DCPD	11DCE	12DCE	12DCLE
BF6	24.50	8.57	0.37	2.25	8.04	*	0.86	*	0.31	*	*	-	0.10
BF7	14.23	9.64	0.08	2.39	9.75	*	0.90	0.11	1.99	0.17	*	-	0.08
RIFS1	--	11.80	*	8.59	6.38	*	1.06	0.32	-	*	*	-	3.41
RIFS1D	--	14.20	*	4.46	5.38	*	10.00	0.06	-	*	*	-	1.09
RIFS2	--	10.90	0.74	9.76	4.65	*	10.00	0.10	-	*	*	-	3.80
PHASE 2 - STAGE 2 (2/16/89 - 5/5/89)													
BF1	24.39	4.08	0.91	3.71	12.51	*	1.11	0.08	0.12	2.54	*	-	0.10
BF2	22.60	3.23	0.23	1.13	5.29	*	0.71	0.08	0.09	0.35	*	-	0.08
BF2C	43.47	2.55	0.41	1.16	8.00	4.00	0.71	*	*	*	*	-	*
BF3	22.49	4.14	0.12	1.38	5.16	*	0.60	0.07	0.09	0.17	*	-	0.10
BF4	17.73	4.34	0.29	0.97	6.66	*	0.48	*	0.09	0.12	*	-	0.06
BF5	7.11	2.44	0.04	0.76	3.34	1.90	0.36	0.09	*	*	*	-	0.07
BF6	6.29	2.60	*	0.87	4.22	*	0.44	0.09	*	*	*	-	*
BF7	16.22	3.10	0.04	0.99	8.54	*	0.26	0.09	*	*	*	-	0.06
RIFS1	--	6.72	*	2.83	8.75	*	0.30	0.17	-	*	*	-	0.21
RIFS1D	--	3.35	*	0.80	1.66	*	0.27	0.12	-	*	*	-	0.14
RIFS2	--	5.73	*	1.24	2.46	*	0.27	*	-	*	*	-	0.34

* All values below CRL.
- Not a target analyte for this site during this phase.

Legend:	ACET	Acetone	CHCL3	Chloreform	12DCLE
	C6H6	Benzene	CLC6H5	Chlorobenzene	1,2-Dichloroethane
	BCHPD	Bicycloheptadiene	CS2	Carbon Disulfide	
	CCL4	Carbon Tetrachloride	DCPD	Dicyclopentadiene	
	111TCE	1,1,1-Trichloroethane	11DCE	1,1-Dichloroethane	
	112TCE	1,1,2-Trichloroethane	12DCE	1,2-Dichloroethenes	

TABLE 4.6-6
(Continued)

	ACET	C6H6	BCHPD	CCL4	111TCE	112TCE	CHCl3	ClC6H5	CS2	DCPD	111DCLE	12DCE	12DCLE
24-HOUR MAXIMUM VALUES													
PHASE 3 (5/6/89 - 9/30/89)													
FC1	--	2.43	*	0.61	1.79	*	0.33	0.07	--	*	*	--	1.52
FC2	--	2.72	*	0.79	1.79	*	0.69	0.07	--	*	*	--	1.38
FC2D	--	2.55	*	0.69	1.77	*	0.76	0.11	--	*	*	--	1.33
BF3/FC3	--	2.78	*	0.97	1.80	*	0.30	0.05	--	*	*	--	1.38
BF4/FC4	--	3.00	*	0.81	2.14	*	0.33	0.05	--	*	*	--	1.55
BF5	--	2.04	*	0.77	1.29	*	0.17	0.08	--	*	*	--	1.30
FC5	--	1.45	*	0.94	1.41	*	0.34	0.05	--	*	*	--	1.31
BF7	--	2.10	*	0.73	2.00	*	0.16	0.07	--	*	*	--	1.29
RIFS1	--	2.57	*	0.55	2.14	*	0.30	0.08	--	*	*	--	1.69
PHASE 4 (10/1/89 - 9/30/90)													
FC1	--	3.53	*	1.43	3.89	*	1.32	0.05	--	*	*	--	1.65
FC2	--	3.17	0.22	1.31	4.17	*	2.23	0.05	--	*	*	--	1.66
FC2D	--	3.16	0.21	1.13	4.33	*	2.21	0.04	--	*	*	--	1.44
FC3	--	3.33	0.07	1.52	4.34	0.06	0.57	0.07	--	*	0.05	--	1.61
FC4	--	2.98	*	1.64	4.60	*	0.54	0.04	--	*	*	--	1.65
FC5	--	3.50	0.05	1.43	3.78	*	1.18	0.04	--	*	*	--	1.63

— Not a target analyte for this site during this phase

* All values below CRL

Legend: ACET Acetone
C6H6 Benzene
BCHPD Bicycloheptadiene
CCL4 Carbon Tetrachloride
111TCE 1,1,1-Trichloroethane
112TCE 1,1,2-Trichloroethane
CHCl3 Chloroform
ClC6H5 Chlorobenzene
CS2 Carbon disulfide
DCPD Dicyclopentadiene
111DCLE 1,1-Dichloroethane
12DCE 1,2 - Dichloroethenes
12DCLE 1,2-Dichloroethane

TABLE 4.6-6
(Continued)

	ACET	C6H6	BCHPD	CCL4	111TCE	112TCE	CHCL3	CLC6H5	CS2	DCPD	11DCE	12DCE	12DCLE
24-HOUR MAXIMUM VALUES													
PHASE 5 STAGE 1 (10/1/90 - 1/18/91)													
FC1	--	9.100	0.070	0.780	4.720	*	0.780	*	--	*	*	--	0.150
FC2	--	4.180	0.180	0.700	5.020	*	0.700	*	--	*	*	--	0.160
FC3	--	3.840	*	0.710	5.810	*	0.710	*	--	*	*	--	0.150
FC4	--	3.770	*	0.710	5.620	*	0.710	*	--	*	*	--	0.160
FC5	--	3.560	0.070	0.730	5.250	*	0.730	*	--	*	*	--	0.170
PHASE 5 STAGE 2 (1/24/91 - 9/30/91)													
FC1	--	2.864	0.046	0.821	3.280	*	1.086	0.061	--	*	*	0.327	0.097
FC2	--	3.210	0.096	1.246	2.918	*	2.674	0.059	--	*	0.061	0.152	0.117
FC3	--	2.773	*	0.848	3.353	*	0.742	*	--	*	*	0.327	0.089
FC4	--	2.794	*	0.882	3.531	*	0.430	*	--	*	*	0.123	*
FC5	--	2.651	*	1.186	2.643	*	2.292	0.052	--	*	*	0.507	0.107

-- Not a target analyte for this site during this phase

* All values below CRL

Legend: ACET Acetone
C6H6 Benzene
BCHPD Bicycloheptadiene
CCL4 Carbon Tetrachloride
111TCE 1,1,1-Trichloroethane
112TCE 1,1,2-Trichloroethane
CHCL3 Chloroform
CLC6H5 Chlorobenzene
CS2 Carbon disulfide
DCPD Dicyclopentadiene
11DCE 1,1-Dichloroethane
12DCE 1,2 - Dichloroethenes
12DCLE 1,2-Dichloroethane

TABLE 4.6-6
(Continued)

	DMDS	ETC6H5	HCBD	MEK	CH2CL2	MIBK	T12DCE	TCLEE	MEC6H5	TRCLE	XYLEN
24-HOUR MAXIMUM VALUES											
PHASE 1 (3/22/88 - 12/12/88)											
BF1	36.72	4.95	--	8.48	54.80	*	*	16.02	35.55	1.47	25.94
BF2	24.06	8.91	--	8.14	55.34	*	*	23.17	90.10	0.78	49.91
BF2C	23.69	4.95	--	4.60	72.36	*	*	9.14	158.04	1.06	17.20
BF3	4.97	3.98	--	5.27	57.64	*	*	2.30	49.41	1.00	10.51
BF4	8.07	2.39	--	5.22	58.14	*	*	3.40	49.91	1.81	10.39
BF5	3.95	2.48	--	6.46	50.81	*	*	3.32	14.49	1.00	10.52
BF6	0.28	1.79	--	5.74	179.09	*	*	2.61	51.49	0.62	12.90
BF7	0.10	2.38	--	4.32	30.26	*	*	2.66	19.61	0.90	11.56
RIFS1	0.11	3.00	--	--	13.70	0.51	*	2.80	16.50	0.26	9.22
PHASE 2 - STAGE 1 (12/13/88 - 2/15/89)											
BF1	*	4.38	*	14.78	23.52	*	*	3.19	13.32	0.57	17.26
BF2	0.08	4.20	*	14.20	15.73	*	*	4.48	11.43	0.34	15.77
BF2C	*	2.25	*	9.56	19.59	*	*	3.49	8.55	0.22	11.22
BF3	*	3.75	*	13.24	23.71	*	*	2.83	11.14	0.34	15.57
BF4	*	8.97	*	13.22	19.77	*	*	5.52	19.52	0.65	28.28

* All values below CRL.

-- Not a target analyte for this site during this phase.

Legend:

DMDS	Dimethyl Disulfide
ETC6H5	Ethylbenzene
HCBD	Hexachlorobutadiene
MEK	Methyl Ethyl Ketone
CH2Cl2	Methylene Chloride
MIBK	Methylisobutylketone
T12DCE	Trans-1,2-Dichloroethene
TCLEE	Tetrachloroethene
MEC6H5	Toluene
TRCLE	Trichloroethene
XYLEN	Xylene

TABLE 4.6-6
(Continued)

	DMDS	ETC6HS	HCBD	MEK	CH2Cl2	MIBK	T12DCE	TCLEE	MEC6HS	TRCLE	XYLEN
24-HOUR MAXIMUM VALUES											
BF5	*	1.99	*	10.54	6.51	*	*	2.58	8.42	0.17	10.39
BF6	*	2.50	*	10.11	2.74	*	*	2.33	6.95	0.47	7.68
BF7	*	2.93	*	8.45	7.56	*	0.05	2.57	7.80	0.44	9.29
RIFS1	*	6.16	--	--	32.50	*	*	3.44	23.90	0.61	15.72
RIFS1D	*	5.69	--	--	22.90	*	*	3.44	30.80	0.32	22.43
RIFS2	*	5.32	--	--	17.00	*	*	2.99	29.60	0.31	19.58
PHASE 2 - STAGE 2 (2/16/89 - 5/5/89)											
BF1	0.05	3.62	*	8.60	28.85	*	*	24.02	6.93	40.43	13.54
BF2	*	1.18	*	7.64	72.80	*	*	2.14	6.22	2.86	6.76
BF2C	*	1.50	*	10.25	59.83	*	*	1.98	8.57	0.47	8.50
BF3	*	1.28	*	7.17	433.69	*	*	2.10	7.49	0.21	7.10
BF4	*	1.72	*	4.83	14.06	*	*	2.04	8.38	0.55	8.92
BF5	*	1.11	*	5.54	5.18	*	*	1.51	5.67	0.15	6.31
BF6	*	0.94	*	7.16	5.74	*	*	1.44	5.22	0.11	5.72
BF7	*	1.11	*	8.85	6.30	*	*	2.27	6.77	0.07	6.25
RIFS1	*	2.28	--	--	20.50	*	*	3.82	21.00	0.21	7.39

* All values below CRL.

-- Not a target analyte for this site during this phase.

Legend:	DMDS	Dimethyl Disulfide
	ETC6HS	Ethylbenzene
	HCBD	Hexachlorobutadiene
	MEK	Methyl Ethyl Ketone
	CH2Cl2	Methylene Chloride
	MIBK	Methylisobutylketone
	T12DCE	Trans-1,2 Dichloroethene
	TCLEE	Tetrachloroethene
	MEC6HS	Toluene
	TRCLE	Trichloroethene
	XYLEN	Xylene

TABLE 4.6-6
(Continued)

	DMDS	ETC6H5	HCBD	MEK	CH2CL2	MIBK	T12DCE	TCLEE	MEC6H5	TRCLE	XYLEN
24-HOUR MAXIMUM VALUES											
RIFS1D	*	1.07	--	--	2.75	*	*	1.67	10.40	0.10	7.01
RIFS2	*	2.06	--	--	4.91	*	*	2.59	16.50	0.07	8.51
PHASE 3 (5/6/89 - 9/30/89)											
FC1	*	1.04	--	--	3.43	0.14	*	1.69	3.24	1.52	3.06
FC2	*	3.99	--	--	3.26	0.18	*	1.35	2.97	0.12	3.31
FC2D	*	1.02	--	--	0.65	0.09	*	1.33	4.40	0.15	3.20
BF3/FC3	*	1.19	--	--	4.24	0.20	*	1.63	2.87	0.09	3.57
BF4/FC4	*	1.25	--	--	4.06	0.21	*	2.50	5.00	0.11	3.48
BF5	*	0.75	--	--	0.44	*	*	1.16	3.25	0.19	2.61
FC5	*	1.05	--	--	6.77	0.15	*	1.44	3.62	0.93	2.51
BF7	*	0.61	--	--	0.74	0.09	*	1.60	2.93	0.07	1.97
RIFS1	*	0.87	--	--	0.92	*	*	1.40	3.54	0.10	3.19
PHASE 4 (10/1/89 - 9/30/90)											
FC1	*	2.27	--	--	2.53	0.63	*	2.38	10.60	0.45	7.07
FC2	*	2.67	--	--	1.98	0.88	*	6.34	10.80	0.23	6.97
FC2D	*	2.62	--	--	1.57	1.13	*	2.59	10.70	0.26	7.04

* All values below CRL.

- Not a target analyte for this site during this phase.

Legend: DMDS Dimethyl Disulfide
ETC6H5 Ethylbenzene
HCBD Hexachlorobutadiene
MEK Methyl Ethyl Ketone
CH2Cl2 Methylene Chloride
MIBK Methylisobutylketone
T12DCE Trans-1,2 Dichloroethene
TCLEE Tetrachloroethene
MEC6H5 Toluene
TRCLE Trichloroethene
XYLEN Xylene

TABLE 4.6-6
(Concluded)

	DMDS	ETC6H5	HCBD	MEK	CH2CL2	MIBK	T12DCE	TCLEE	MEC6H5	TRCLE	XYLEN
24-HOUR MAXIMUM VALUES											
FC3	*	2.84	--	--	1.60	0.84	0.06	5.98	10.90	0.30	7.07
FC4	*	3.01	--	--	2.03	1.13	*	3.51	9.93	0.30	6.62
FC5	*	2.24	--	--	1.45	0.75	*	2.91	10.60	0.50	7.09
PHASE 5 (10/1/90 - 1/18/91)											
FC1	*	1.700	--	--	--	--	--	2.190	9.720	0.150	5.110
FC2	*	1.940	--	--	--	--	--	2.270	10.700	0.170	5.690
FC3	*	1.950	--	--	--	--	--	2.100	10.800	0.180	6.060
FC4	*	1.990	--	--	--	--	--	2.290	10.600	0.160	5.920
FC5	*	1.650	--	--	--	--	--	2.040	9.260	0.170	5.000
PHASE 5 STAGE 2 (1/24/91 - 9/30/91)											
FC1	*	0.976	--	--	3.470	*	--	1.472	3.785	0.122	4.740
FC2	*	1.020	--	--	7.640	*	--	1.560	3.785	0.077	6.240
FC3	*	0.542	--	--	1.170	*	--	1.082	4.480	0.127	2.624
FC4	*	1.436	--	--	1.320	*	--	1.233	3.756	0.106	7.239
FC5	*	1.080	--	--	1.840	*	--	2.290	3.720	0.120	4.750

* All values below CRL.

- Not a target analyte for this site during this phase.

Legend:

DMDS	Dimethyl Disulfide
ETC6H5	Ethybenzene
HCBD	Hexachlorobutadiene
MEK	Methyl Ethyl Ketone
CH2Cl2	Methylene Chloride
MIBK	Methylisobutylketone
T12DCE	Trans-1,2 Dichloroethene
TCLEE	Tetrachloroethene
MEC6H5	Toluene
TRCLE	Trichloroethene
XYLEN	Xylene

TABLE 4.6-7
**MAXIMUM CONCENTRATIONS AND LOCATIONS OF
 VOLATILE ORGANIC COMPOUNDS (in $\mu\text{g}/\text{m}^3$)**

VOC	Maximum Long-Term Average			Maximum 24-Hour Concentration			
		Location	Phase	Location	Phase	Location	Phase
1,1,1-Trichloroethane	10.53	BF4	P1	72.54		BF1	P1
1,1,2-Trichloroethane	0.46	BF2	P2-S2	4.00		BF2	P2-S2
1,1-Dichloroethane	0.14	CMP/BF3	P1	0.27		CMP/BF3	P1
1,2-Dichloroethenes	0.09	QI2	P5	0.51		FCS	P5
1,2-Dichloroethane	0.49	AQ5	P2-S2	3.80		RIFS2	P2-S1
Bicycloheptadiene	9.96	BF2	P1	39.46		BF2	P1
Benzene	10.53	CMP/BF1	P1	44.29		CMP/BF1	P1
Carbon Tetrachloride	1.99	RIFS2	P2-S1	9.76		RIFS2	P1
Methylene Chloride	24.01	AQ5	P3	433.69		BF3	P2-S1
Chloroform	6.95	BF2	P1	37.15		BF2	P2-S2
Chlorobenzene	0.47	CMP/BF2	P1	2.53		CMP/BF2	P1
Dibromochloropropane	2.90	CMP/BF2	P1	17.04		CMP/BF2	P1
Dicyclopentadiene	4.53	BF2	P1	29.12		BF2	P1
Dimethyl Disulfide	7.86	BF1	P1	36.72		BF1	P1
Ethylbenzene	2.39	CMP/BF2	P1	13.04		CMP/BF2	P1
Toluene	23.55	BF2	P1	158.04		BF2	P1
Methylisobutylketone	0.47	AQ6	P3	1.13		FC4	P4
N-Nitrosodimethylamine	ND						
Dimethylbenzene	3.06	RIFS2D	PS-S1	8.03		RIFS2D	P2-S1
Trans-1,2-Dichloroethane	0.02	BF7	P2-S1	0.06		FC3	P4
Tetrachloroethene	5.29	BF1	P2-S2	24.02		BF1	P2-S2
Trichloroethene	6.98	BF1	P2-S2	40.43		BF1	P2-S2
Xylene	8.57	BF2	P1	49.91		BF2	P1

Note: Data from both within and above the certified range are summarized here. Long-term refers to averages by phase.

- P1 = Phase 1
- P2-S1 = Phase 2 - Stage 1
- P2-S2 = Phase 2 - Stage 2
- P3 = Phase 3
- P4 = Phase 4
- P5 = Phase 5

TABLE 4.6-8

**COMBINED SEASONAL AVERAGE VOC CONCENTRATIONS (in $\mu\text{g}/\text{m}^3$)
(FY88, FY89, FY90 AND FY91)**

Season		111TCE	112TCE	11DCLE	12DCE	12DCLE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3	CLC6H5	DBCP
Winter	AQ1	1.007	*	*	--	0.118	*	1.394	0.767	3.251	0.180	*	*
	AQ2	1.549	*	*	0.033	0.029	*	1.952	0.614	--	0.438	*	--
	AQ3	1.052	*	*	*	0.077	*	1.119	0.418	1.303	0.119	*	*
	AQ4	1.009	*	*	--	0.090	*	0.930	0.768	1.302	0.086	*	--
	AQ5	2.411	*	*	*	0.082	*	1.385	0.656	3.849	0.151	*	*
Spring	AQ1	1.395	*	*	*	0.111	*	2.175	0.396	2.027	0.069	*	*
	AQ2	0.942	*	*	0.053	0.150	*	1.513	0.477	1.246	0.047	0.023	*
	AQ3	0.980	*	*	0.042	0.124	*	0.888	0.435	0.987	0.056	*	*
	AQ4	1.196	*	*	*	*	*	0.967	0.306	0.556	0.041	*	--
	AQ5	1.889	*	*	0.033	0.163	*	1.276	0.491	2.295	0.050	*	*
Summer	AQ1	1.479	*	*	--	0.052	*	2.589	0.409	7.426	0.232	0.027	*
	AQ2	1.457	*	*	0.052	*	*	1.141	0.376	19.348	0.039	*	*
	AQ3	1.060	*	*	0.061	0.051	*	1.455	0.363	3.844	0.129	*	*
	AQ4	1.274	*	*	--	0.081	*	1.702	0.402	4.751	0.138	*	*
	AQ5	1.985	*	*	0.047	0.045	*	1.777	0.402	7.140	0.114	*	*
	AQ6	3.454	*	*	--	0.039	*	1.690	0.425	3.929	0.171	*	*
	AQ8	1.277	*	*	--	*	0.450	3.040	0.322	4.831	7.224	*	*
	AQ9	1.420	*	*	--	*	*	1.996	0.481	5.078	0.218	*	*
	AQ10	1.725	*	*	*	*	0.072	1.450	0.607	5.534	0.223	*	*
	AQ01	1.496	*	*	*	0.038	0.043	1.306	0.415	3.159	0.676	0.036	*

TABLE 4.6-8
(Continued)

Season		111TCE	112TCE	11DCL _E	12DCE	12DCL _E	BCHPD	C ₆ H ₆	CCL ₄	CH ₂ CL ₂	CHCl ₃	CLC ₆ H ₅	DBCP	
	AQ02	4.115	*	*	-	*	*	1.898	0.337	13.281	0.208	*	*	
	AQ23	2.305	*	*	-	*	0.089	*	1.415	0.585	7.578	0.584	*	*
	AQ25	0.420	*	*	*	*	*	0.677	0.278	-	0.021,	*	-	
	AQ26	1.215	*	0.040	-	0.045	0.533	2.886	0.415	8.195	0.737	0.164	0.574	
	AQ35	1.323	*	*	-	0.097	*	1.220	0.401	1.372	0.080	*	*	
	AQ36	1.648	*	*	-	*	0.101	0.916	0.725	4.991	0.865	*	*	
Fall	AQ1	4.021	*	*	-	*	*	4.453	0.909	4.578	0.233	*	*	
	AQ2	2.450	*	*	-	*	*	4.282	0.354	3.995	0.365	*	*	
	AQ3	2.640	*	*	-	0.081	0.035	2.696	0.670	2.217	0.377	*	*	
	AQ4	3.521	*	*	-	*	*	4.640	0.996	2.208	0.294	*	*	
	AQ5	6.212	*	*	-	0.092	*	5.970	0.928	3.361	0.110	*	*	

* All values below CRL
- Not analyzed

Legend: 111TCE 1,1,1-Trichloroethane
112TCE 1,1,2-Trichloroethane
11DCL_E 1,1-Dichloroethane
12DCE 1,2-Dichloroethenes
12DCL_E 1,2-Dichloroethane
BCHPD Bicycloheptadiene

C₆H₆ Benzene
CCL₄ Carbon Tetrachloride
CH₂CL₂ Methylene Chloride
CHCl₃ Chloroform
CLC₆H₅ Chlorobenzene
DBCP Dibromochloropropane

TABLE 4.6-8
(Continued)

Season		DCPD	DMDS	ETC6H5	MEC6H5	MIBK	NNDMEA	DMB12	T12DCE	TCLEE	TRCLE	XYLENE
Winter	AQ1	*	*	0.885	4.427	*	*	0.982	*	1.308	0.116	0.869
	AQ2	*	*	0.485	3.220	*	--	--	--	0.573	0.054	2.235
	AQ3	*	*	0.301	3.418	*	*	0.462	*	0.498	0.040	0.972
	AQ4	*	*	0.275	3.325	*	*	0.408	*	0.393	0.040	0.870
	AQ5	*	*	0.457	3.982	*	*	0.484	*	1.511	0.042	1.602
Spring	AQ1	*	*	0.686	6.688	0.098	*	0.847	*	0.880	0.121	2.624
	AQ2	*	*	0.414	4.773	*	*	0.587	*	1.010	0.045	1.643
	AQ3	*	*	0.196	2.600	*	*	0.256	*	0.680	0.027	0.695
	AQ4	*	*	0.383	2.776	*	--	--	--	0.395	*	1.684
	AQ5	*	*	0.408	5.731	*	*	0.729	*	1.906	0.029	1.559
Summer	AQ1	*	*	0.617	9.085	0.112	*	0.844	*	0.807	0.107	2.414
	AQ2	*	*	0.232	5.760	*	*	0.257	*	0.304	0.066	1.174
	AQ3	*	*	0.238	3.296	0.076	*	0.326	*	0.508	0.067	1.408
	AQ4	*	*	0.269	8.933	*	*	0.371	*	0.490	*	1.170
	AQ5	*	*	0.490	5.424	*	*	0.588	*	1.245	0.069	1.901
	AQ6	*	*	0.228	4.029	0.318	*	0.285	*	0.569	0.082	0.870
	AQ8	*	*	0.203	4.221	*	*	0.221	*	0.359	0.137	1.424
	AQ9	*	*	0.183	2.237	*	*	0.224	*	0.346	0.120	0.848
	AQ10	*	0.095	0.297	4.370	*	*	0.247	*	0.621	0.078	1.172
	AQ01	0.156	*	0.304	3.848	0.086	*	0.319	*	0.556	0.044	1.257
	AQ02	*	*	0.452	5.651	0.251	*	0.501	*	1.336	0.124	1.331
	AQ23	*	*	0.371	7.036	*	*	0.496	*	0.664	0.165	1.103

TABLE 4.6-8
(Concluded)

Season	AQ25	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	NNDMA	DMB12	T12DCE	TCLEE	TRCLE	XYLENE
Fall	AQ26	0.381	0.162	0.662	4.717	0.054	*	0.328	*	0.632	0.183	1.430
	AQ35	*	*	0.451	3.490	*	*	0.518	*	0.676	*	1.374
	AQ36	*	*	0.216	3.675	0.076	*	0.343	*	0.539	0.254	1.248
	AQ1	*	*	3.975	6.167	0.525	*	5.144	*	4.276	0.229	6.282
	AQ2	0.574	*	1.677	11.333	*	*	2.513	*	3.349	0.090	1.890
	AQ3	*	*	1.943	4.971	0.228	*	2.685	*	2.451	0.117	3.737
	AQ4	*	*	2.962	1.658	0.546	*	3.431	*	2.286	0.148	5.205
	AQ5	*	*	2.262	7.502	0.350	*	3.249	*	3.722	0.194	4.676
	*	All values below CRL										
	--	Not analyzed										

* All values below CRL
-- Not analyzed

Legend: DCPD Dicyclopentadiene
DMDS Dimethyl Disulfide
ETC6H6 Ethylbenzene
MEC6H5 Toluene
MIBK Methylisobutylketone
NNDMA N-Nitrosodimethylamine

DMB12 Dimethylbenzene
T12DCE Trans -1,2-Dichloroethane
TCLEE Tetrachloroethene
TRCLE Trichloroethene
XYLENE Xylenes

TABLE 4.6.9
**VOLATILE ORGANIC COMPOUNDS (VOC) SOURCES
 WITH EMISSIONS GREATER THAN 10 TPY**

County	UTM/E	UTM/N	Map #	Plant Name	Emissions (tpy)	Percent Tri-County Total
Adams	504.7	4405.8	1	Colorado Refining Co.	971	13.9
Adams	504.5	4405.5	2	Conoco Inc.	746	10.7
Adams	509.7	4413.3	3	Sinclair Pipeline Co.	354	5.1
Denver	507.4	4402.2	4	Pillow Kingdom Mfg.	338	4.8
Adams	507.3	4410.3	5	Wyco Pipeline Co.	204	2.9
Denver	512.0	4403.0	6	Continental Airlines	158	2.3
Denver	501.0	4394.2	7	Gates Rubber Co.	153	2.2
Adams	520.6	4402.5	8	Mastercraft	125	1.8
Adams	515.5	4424.5	9	Alltac Corp.	118	1.7
Denver	507.0	4403.5	10	Shafer Comm. Seating	99	1.4
Adams	440.0	5010.7	11	Advance Foam Plastic Inc.	96	1.4
Adams	504.9	4405.2	12	Diamond Shamrock Corp.	96	1.4
Denver	501.1	4400.7	13	Benjamin Moore & Co.	95	1.4
Adams	516.0	4401.0	14	Chase Terminal Co.	83	1.2
Adams	504.9	4405.2	15	Phillips Pipeline Co.	81	1.2
Adams	503.0	4406.2	16	PSCO Cherokee Plant	63	0.9
Denver	499.7	4398.4	17	Union Chemicals Division	60	0.9
Adams	501.0	4404.5	18	Cobitco Inc.	57	0.8
Denver	501.0	4403.1	19	Energy Thermal Systems	55	0.8
Denver	507.9	4403.9	20	Ambassador Drapery Clr.	54	0.8
Adams	499.9	4417.6	21	AT&T Information Systems	54	0.8
Adams	499.5	4405.6	22	American Blackline Coatings Inc.	53	0.8
Denver	511.5	4403.7	23	Scott's Liquid Gold	48	0.7
Adams	510.0	4412.8	24	Oil & Solvent Process Co.	47	0.7
Denver	509.5	4397.0	25	Lowry Air Force Base	44	0.6
Arapahoe	497.5	4388.5	26	Modern Plastics Inc.	41	0.6
Denver	510.0	4400.0	27	E/M Corporation	37	0.5
Adams	500.2	4405.3	28	Atlas/Judds Bros.	35	0.5
Adams	501.6	4409.2	29	Hughes and Company	34	0.5
Adams	515.0	4403.2	30	Denver Auto Auction	34	0.5
Arapahoe	498.7	4389.3	31	Ashland Chemical Co.	33	0.5
Denver	503.2	4404.1	32	Power Assist. Co. Inc.	33	0.5
Adams	526.1	4399.8	33	Amoco Prod. Co. - Natterberg	31	0.4
Adams	507.5	4408.6	34	Rainbo Bread Co.	31	0.4
Denver	504.8	4402.9	35	The Denver Post Corp.	31	0.4
Denver	498.0	4391.5	36	Import Auto Body	30	0.4
Denver	500.5	4398.7	37	Rocky Mountain News	30	0.4
Denver	499.6	4398.3	38	Komac Paint Company	29	0.4
Denver	499.9	4394.3	39	Denver Industrial Sales	29	0.4
Arapahoe	499.0	4390.0	40	Sterling Stainless Tube	29	0.4
Adams	524.7	4400.5	41	Colorado Interstate Gas	29	0.4
Denver	512.4	4404.2	42	Pease Industries Inc.	28	0.4

TABLE 4.6-9
(Continued)

County	UTM/E	UTM/N	Map #	Plant Name	Emissions (tpy)	Percent Tri-County Total
Denver	500.6	4395.6	43	Pharmaceuticals Basics Inc.	27	0.4
Arapahoe	506.2	4380.2	44	Electromedics Inc.	27	0.4
Arapahoe	499.5	4386.7	45	Thomas Plating Co.	26	0.4
Adams	503.8	4406.5	46	Metro Denver Sewage Disp.	25	0.4
Denver			47	Conoco Inc. - Federal	25	0.4
Denver	511.7	4404.2		Chemical Systems Techn.	24	0.3
Denver	504.0	4402.9		American Coil Coating Inc.	21	0.3
Denver	502.9	4399.5		Presbyterian/St. Luke's	20	0.3
Adams	505.5	4405.9		United Asphalts Inc.	19	0.3
Denver	499.8	4390.9		PSCO Arapahoe Plant	19	0.3
Arapahoe	520.0	4395.6		Buckley ANG	19	0.3
Denver	507.1	4402.7		Daralco Inc.	18	0.3
Denver	501.5	4400.8		City-Elite Cleaners	18	0.2
Denver	500.8	4401.1		B-D Chemical Co. Inc.	17	0.2
Denver	511.9	4402.1		Kwal Paints Inc.	17	0.2
Denver	500.1	4402.6		Brannan Sand & Gravel	17	0.2
Adams	501.9	4410.3		W.J. Whatley Inc.	17	0.2
Adams	497.9	4403.5		Exxon Corp. - Federal	17	0.2
Adams	511.2	4398.8		Exxon Corp. - Colfax	17	0.2
Adams	494.7	4405.2		American Precision Plastics	17	0.2
Denver	506.3	4402.8		Stemco Manufacturing	16	0.2
Denver	506.9	4342.2		Redfield Riflescope Inc.	16	0.2
Denver	512.4	4402.2		Frito-Lay Inc.	16	0.2
Arapahoe	499.0	4385.8		Electron Corporation	16	0.2
Arapahoe	490.5	4391.0		Denver Forms	16	0.2
Arapahoe	495.5	4379.5		T.A. Pelsue	15	0.2
Arapahoe	501.0	4291.6		Total Petroleum - Arapahoe	15	0.2
Adams	503.2	4415.4		Future Foam Corp.	15	0.2
Adams	510.6	4399.8		Stanley Aviation Corp.	15	0.2
Adams	502.0	4408.5		C&M Press Inc.	13	0.2
Denver				Conoco Inc. - Sheridan Blvd.	13	0.2
Denver	525.9	4414.8		Koch Hydrocarbon Co.	13	0.2
Arapahoe	501.0	4384.0		Western Pump-It Inc.	13	0.2
Adams	501.0	4411.0		Phillips 66 Co. - Broomfield	13	0.2
Adams	501.3	4426.3		O'Meara Body & Paint	12	0.2
Arapahoe	520.0	4385.0		Phillips 66 - Sheridan Blvd.	12	0.2
Arapahoe	500.0	4390.0		Conoco Inc. - Quincy	12	0.2
Denver	497.8	4293.2		Total Petroleum - Federal	12	0.2
Denver	502.0	4404.0		Ardco	12	0.2
Denver				Conoco Inc. - Colo. Blvd.	11	0.2
Denver	501.1	4397.4		Rickenbaugh Cadillac Co.	11	0.2
Denver	507.8	4402.1		Esquire Valet	11	0.2
Denver	505.9	4402.3		Kistler Graphics Inc.	11	0.2
Arapahoe	499.5	4387.5		Sams Service Inc.	11	0.2

TABLE 4.6-9
(Concluded)

County	UTM/E	UTM/N	Map #	Plant Name	Emissions (tpy)	Percent Tri-County Total
Arapahoe	515.0	4400.0		Conoco Inc. - Iliff Ave.	11	0.2
Arapahoe	511.0	4388.0		Conoco Inc. - Havana St.	11	0.2
Arapahoe	499.7	4387.8		Martin Shipper Supply Inc.	11	0.2
Adams	505.0	4412.0		Conoco Inc. - E. 84th Ave.	11	0.2
Adams	504.0	4411.0		Conoco Inc. - Federal Blvd.	11	0.2
Adams	519.0	4401.5		Conoco Inc. - E. Colfax Ave.	11	0.2
Adams	513.6	4408.3	48	RMA	2	
TRI-COUNTY TOTALS					6,978	80.1

Source: Colorado Department of Health EISPS Inventory, May, 1992.

Legend: UTM/E = Universal Transverse Mercator East Coordinate
 UTM/N = Universal Transverse Mercator North Coordinate
 TPY = Tons per year

TABLE 4.6-10
TOTAL POUNDS OF RELEASES OF TOXIC CHEMICALS BY FACILITY AND TOXICITY
FOR DENVER AND ADAMS COUNTIES

Facility	Carcinogen	Heritable Mutagen	Developmental Toxin	Reproductive Toxin	Acute Toxin	Chronic Toxin	Neurotoxin
Aaa Plating	0	0	0	0	750	750	0
A.B. Hirschfield Press Inc.	0	0	17236	17236	0	17236	0
Alltac Corp.	0	0	84874	84874	0	0	0
Ardco Corp.	0	0	15000	15000	0	15000	15000
Asarco Inc., Globe Plant	0	0	0	0	752	752	0
AT&T	15150	0	4	4	15	30702	4
Benjamin Moore & Co.	0	0	0	0	0	106	0
Birko	0	0	0	0	250	250	0
Boyles Galvanizing Co.	0	0	0	0	70205	70205	0
Cai	0	0	0	0	500	0	0
Chemical & Metal Ind. Inc.	17402	0	17402	10300	750	18152	0
Chemrex Inc.	11709	0	1110	1110	0	0	0
Cobitco Inc.	0	0	0	0	33	33	0

TABLE 4.6-10
(Continued)

Facility	Carcinogen	Heritable Mutagen	Developmental Toxin	Reproductive Toxin	Acute Toxin	Chronic Toxin	Neurotoxin
Colorado Refining Co.	9441	0	21024	21024	7329	23078	0
Conoco Denver Refinery	6498	0	78775	78775	370	81739	6357
Cryenco	0	0	6300	6300	0	0	0
Daniel Radiator	0	0	1000	1000	0	0	500
DPC	0	0	0	0	750	750	0
E/M	0	0	10887	10887	0	10887	10887
Entenmann's	0	0	0	0	750	0	0
Future Foam	22754	0	0	0	500	0	0
Gates Rubber Co.	6200	0	127300	127300	0	7100	0
Jackson Ice Cream Co.	0	0	0	0	5500	5500	0
Koppers Ind. Inc.	382	0	180	180	0	4536	0
Kwal-Howells Inc.	0	0	0	0	0	500	0
Mesa Fiberglass Inc.	29880	29880	0	0	0	29880	0
Mid-America Plating Inc.	0	0	0	0	750	500	0
Modine Western-Rocky Mt.	0	0	102	102	0	0	0

TABLE 4.6-10
(Continued)

Facility	Carcinogen	Heritable Mutagen	Developmental Toxin	Reproductive Toxin	Acute Toxin	Chronic Toxin	Neurotoxin
NER Data Products, Inc.	0	0	7715	7715	0	0	0
Pease	0	0	28000	28000	0	28000	28000
Pepcol	0	0	0	0	55250	55250	0
Pillow Kingdom	0	0	84956	84956	0	59754	12241
Pillow Kingdom	0	0	84956	84956	0	22577	12241
Prokrete In. Prochem Tech	0	0	3250	3250	0	3250	0
Protecto Wrap Co.	0	0	1773	1773	0	765	302
Redfield Riflescopes Inc.	0	0	28200	28200	0	0	0
RMO	0	0	0	0	4	4	0
Rocky Mtn. Prestress	750	750	0	0	33500	46950	0
Safeway Dist.	0	0	0	0	9700	9700	0
Samsonite Corp.	0	0	105268	105268	0	0	0
Sashco Inc.	0	0	250	250	0	1000	0
Sashco Inc.	0	0	0	0	0	1000	0
Scott's Liquid Gold Inc.	0	0	1000	1000	0	0	0

TABLE 4.6-10
(Concluded)

Facility	Carcinogen	Heritable Mutagen	Developmental Toxin	Reproductive Toxin	Acute Toxin	Chronic Toxin	Neurotoxin
Shafer Commercial Seating	78	78	39946	39994	30	45576	19876
Silver Eng.	489	0	232	232	0	489	0
Stanley Aviation Corp.	33400	0	51240	51240	0	33400	0
Sunstrand Aviation Oper.	52208	0	233909	233909	13720	103106	2926
Thompson Pipe & Steel Co.	0	0	27806	27806	0	27806	46
W.J. Whatley Inc.	1400	1400	0	0	0	38991	0
Whirlpool Kitchens Inc.	0	0	16603	16603	0	0	0
Whittaker Power Storage	0	0	0	0	125	125	0
Wright & McGill Co.	500	0	500	500	0	500	0

Source: "Poisons in Our Neighborhoods, Toxic Pollution in Colorado." Citizens Fund, Washington, D.C., Appendix VIII, June 1990.

TABLE 4.6-11

RELEASES OF TOXIC CHEMICALS IN POUNDS FOR DENVER AND ADAMS COUNTIES

Facility	Releases to Air	Percent of Total for County	County	Major Components of Release
Sundstrand Aviation Oper.	203893	24.28	Denver	111TCE, freon 113, Tetrachloroethylene, et al.
Conoco Denver Refinery	166090	23.09	Adams	Propylene, xylenes, toluene, Ethylene, et al.
Pillow Kingdom	122133	14.54	Denver	Toluene, 111TCE, MEK, Xylenes, acetone, et al.
Samsonite Corp.	105628	12.58	Denver	111TCE, MEK
Pillow Kingdom	84956	10.12	Denver	Toluene, 111TCE, MEK
Alltac Corp.	84124	11.69	Adams	Toluene, MEK
Gates Rubber Co.	79872	9.51	Denver	Toluene, 111TCE, Tetrachloroethylene, zinc
Shafer Commercial Seating	73759	8.78	Denver	Xylene, toluene, MIBK, Methanol, 111TCE, et al.
Stanley Aviation Corp.	51240	7.12	Adams	111TCE, tetrachloroethylene
W.J. Whatley Inc.	38991	5.42	Adams	Acetone, styrene
Colorado Refining Co.	33215	4.62	Adams	Cyclohexane, benzene, Xylenes, toluene, et al.
Redfield Riflescopes Inc.	28200	3.36	Denver	111TCE, aluminum
Thompson Pipe & Steel Co.	22652	2.70	Denver	Xylenes
Ardco Corp.	15000	1.79	Denver	MEK
A.B. Hirschfield Press Inc.	12927	1.54	Denver	Xylenes
Chemrex Inc.	12819	1.54	Adams	Dichloromethane
Mesa Fiberglass Inc.	9960	1.38	Adams	Acetone, styrene
Whirlpool Kitchens Inc.	9929	1.38	Adams	Toluene, MIBK, xylenes
NER Data Products, Inc.	6715	8.00	Denver	Toluene, 111TCE
Cyrenco	5100	0.61	Denver	111TCE
Chemical & Metal Ind. Inc.	2000	0.24	Denver	1122Tetrachloroethane, Antimony, CCL4, et al.

**TABLE 4.6-11
(Concluded)**

Facility	Releases to Air	Percent of Total for County	County	Major Components of Release
Protecto Wrap Co.	1773	0.21	Denver	Xylenes
Koppers Ind. Inc.	1745	0.21	Denver	Naphthalene, dibenzofuran, Anthracene
Boyles Galvanizing Co.	1740	0.24	Adams	Hydrochloric acid, zinc
Asarco Inc., Globe Plant	1091	0.13	Denver	Cadmium, lead, sulfuric acid, Zinc, et al.
Scott's Liquid Gold Inc.	750	0.09	Denver	111TCE
Mid-America Plating Inc.	750	0.09	Denver	Hydrochloric acid, nitric acid, sulfuric acid
Jackson Ice Cream Co.	500	0.06	Denver	Ammonia
Kwal-Howells Inc.	250	0.03	Denver	Ethylene glycol
Atlas Energy Products	250	0.03	Denver	Phenylisocyanate
Sashco Inc.	250	0.03	Adams	Toluene
Prokrete Inc. Prochem Tech	250	0.03	Denver	Xylenes
Benjamin Moore & Co.	134	0.01	Denver	Ethylene glycol, zinc
Whittaker Power Storage	125	0.01	Denver	Sulfuric acid
Modine Western-Rocky Mt.	102	0.01	Denver	Copper
Cobitco Inc.	33	0.00	Denver	Hydrochloric Acid
Pepsi-Cola Bottling Co.	0	0.00	Denver	--
Safeway Milk Plant	0	0.00	Denver	--
Wright & McGill Co.	0	0.00	Denver	--
Total for Denver County	839771			
Total for Adams County	719355			

Source: "Poisons in Our Neighborhoods, Toxic Pollution in Colorado." Citizens Fund, Washington, DC, Appendices II and IX, June 1990, updated by facility-specific data in July 1991 report in Appendices IV and X.

TABLE 4.6-12

**RMA TARGET VOLATILE ORGANIC COMPOUNDS (VOC)
COMPARISON TO HEALTH GUIDELINES FOR PHASES 1 AND 2**

Target Name	CAS #	TLV (ppm)	TLV/420 (µg/m³)	Chronic RBAC* (µg/m³)				RMA Phases 1 and 2				RMA CMP Boundary Evaluation**				
				Lifetime Excess Cancer Risk Level		Typical Guidelines* (µg/m³)	Annual	24-Hr	Long-Term	24-Hr	Long-Term	24-Hr	Long-Term	24-Hr	Long-Term	
				10 ⁻⁴	10 ⁻⁶											
1,1,1-Trichloroethane	71-55-6	350	4948	1000	1040-191000	1040-38400	72.54	10.53	<1	<1	5.26	2.45	<1	<1	<1	
1,1,2-Trichloroethane	79-00-5	10	141	6	0.06	14.8-1070	0.06-355	4.00	0.46	<1	<1	ND	ND	ND	ND	ND
1,1-Dichloroethane	75-24-3	200	2105	4	0.04	960-81000	0.038-400	0.27	0.14	<1	<1	ND	ND	ND	ND	ND
1,2-Dichloroethane	107-06-2	10	105	4	0.04			3.80	0.49			0.50	0.50			
Bicycloheptadiene	121-46-0							39.46	9.96			0.39	0.12			
Benzene	71-43-2	10	83	10	0.1		1.74-714	0.10-72	44.29	10.53	12	29	13.38	4.35	4	
Carbon Tetrachloride	56-23-5	5	82	7	0.07		30.2-714	0.03-100	9.76	1.99	3	4	2.28	0.91	<1	
Methylene Chloride	75-09-2	50	452	200	2	3000	945-17400	0.2-27	433.69	23.81	5	>100	7.79	4.00	<1	
Chloroform	67-66-3	10	126	4	0.04		23.5-1200	0.04-167	37.15	6.95	6	8	2.90	0.82	<1	
Chlorobenzene	108-90-7	10	109.52	20					2.53	0.47			0.23	0.09		
Dibromochloropropane	94-12-8	0.001	0.02	0.0002			0.00016-0.001	17.04	2.90	>100	>100	ND	ND	ND	ND	ND
Dicyclopentadiene	77-73-6	5	70.26	0.2		31-714	27	29.12	4.53	8	17	0.57	0.57	<1	<1	2
Dimethyl disulfide	624-92-0							36.72	7.86			ND	ND	ND	ND	ND
Ethylbenzene	100-41-4	100	1127			1000	118-43500	118-1450	13.04	2.39	<1	<1	2.66	1.68	<1	<1
Toluene	108-88-3	100	978			2000	900-8930	10.2-7500	158.04	23.55	3	1	34.44	11.64	<1	<1
Methylisobutyl ketone	108-10-1	50	531.46	80				0.51	0.10			0.24	0.08			
N-Nitrosodimethylamine	62-75-9					N/A	0.00071-0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dimethylbenzene	95-47-6	100	1126.70			300	4350	1450	8.03	3.06	<1	<1	4.42	2.51	<1	<1
Trans-1,2-Dichloroethene	156-60-5	200	2062				7900	790	0.05	0.02	<1	<1	ND	ND	ND	ND
Tetrachloroethene	127-18-4	50	882	200	2		340-13700	0.02-34	24.02	5.29	<1	31	3.92	3.35	<1	20
Trichloroethene	79-01-6	50	696	60	0.6		36.5-6750	0.3-135	40.43	6.98	1	10	0.31	0.11	<1	<1
Xylene	108-38-3	100	1126.70	300			11.8-8680	11.8-1450	49.91	8.57	1	1	4.85	3.76	<1	<1
1,2-Dichloroethene	540-59-0	200	1881				2900-79000	79-108	—	—	—	—	—	—	—	—

* Range of values represent upper and lower bound state guideline levels as found in NATICH.

** Based on arithmetic average of upper and lower bound guideline values.

— Data from both within and above the certified range are summarized here.

TABLE 4.6-12
(Concluded)

-- Not analyzed during these phases

Legend: TLV = Threshold Limit Value

RBAC* = Risk-based air concentration for long-term (lifetime) residential exposures. RBACs for carcinogens are derived from unit risks reported in EPA's Integrated Risk Information System (IRIS) database or EPA's Health Effects Assessment Summary Tables (HEAST 1992). RBACs for noncarcinogens are Reference Concentrations (RfCs) reported in the same documents.

TABLE 4.6-13

**RMA TARGET VOLATILE ORGANIC COMPOUNDS (VOC)
COMPARISON TO HEALTH GUIDELINES FOR PHASES 3, 4, AND 5**

Target Name	CAS #	TLV (ppm)	TLV/ ($\mu\text{g}/\text{m}^3$)	Chronic RBAC ^c ($\mu\text{g}/\text{m}^3$)				RMA CMP Boundary Evaluation ^a			
				Lifetime Excess Cancer Risk Level		Typical Guidelines ^b ($\mu\text{g}/\text{m}^3$)	Shrt-term Annual	24-Hr	Long- Term	24-Hr	Long- Term
				10 ⁻⁴	10 ⁻⁶						
1,1,1-Trichloroethane	71-55-6	350	4948	1000	1040-191000	1040-38400	4.98	4.11	<1	7.16	3.22
1,1,2-Trichloroethane	79-00-5	10	141	6	0.06	14.8-1070	0.06-355	0.06	<1	ND	ND
1,1-Dichloroethane	75-34-3	200	2105	500	960-81000	0.038-400	0.06	0.02	<1	ND	ND
1,2-Dichloroethane	107-06-2	10	105	4	0.04		0.25	0.10		0.20	0.08
Bicycloheptadiene	121-46-0									ND	ND
Benzene	71-43-2	10	83	10	0.1	1.74-714	0.10-72	9.10	3.31	3	7.55
Carbon Tetrachloride	56-23-5	5	82	7	0.07	30.2-714	0.03-100	1.93	1.36	1	1.79
Methylene Chloride	75-09-2	50	452	200	2	3000	9.45-17400	0.2-27	19.84	13.30	<1
Chloroform	67-66-3	10	126	4	0.04	23.5-1200	0.04-167	3.53	1.68	<1	2
Chlorobenzene	108-90-7	10	109.52		20			0.11	0.03	0.06	0.02
Dibromochloropropane	94-12-8	0.001	0.025	0.0002		0.01-0.05	0.00016-0.001	ND	ND	ND	ND
Dicyclopentadiene	77-73-6	5	70.26		0.2	31-714	27	1.12	ND	6	ND
Dimethyl disulfide	624-92-0							ND	ND	ND	ND
Ethylbenzene	100-41-4	100	1127		1000	118-43500	118-1450	3.99	0.65	<1	5.29
Toluene	108-88-3	100	978		2000	900-8930	10.2-7500	11.38	9.16	<1	16.88
Methylisobutyl ketone	108-10-1	50	531.46		80			1.13	0.25	1.04	0.26
N-Nitrosodimethylamine	62-75-9					N/A	0.00071-0.05	ND	ND	ND	ND
Dimethylbenzene	95-47-6	100	1126.70		300	4350	1450	1.00	0.74	<1	5.87
Trans-1,2-Dichloroethene	156-60-5	200	2062			7900	790	0.06	0.02	<1	ND
Tetrachloroethene	127-18-4	50	882	200	2	340-13700	0.02-34	6.34	1.34	8	5.89
Trichloroethene	79-01-6	50	696	60	0.6	36.5-6750	0.3-135	1.52	0.61	1	0.32
Xylene	108-38-3	100	1126.70		300	11.8-8680	11.8-1450	10.08	3.53	<1	10.08

TABLE 4.6-13
(Concluded)

Target Name	CAS #	TLV (ppm)	TLV/420 ($\mu\text{g}/\text{m}^3$)	Chronic RBAC* ($\mu\text{g}/\text{m}^3$)			RMA Phases 3, 4 and 5			RMA CMP Boundary Evaluation**		
				Lifetime Excess Cancer Risk Level	Typical Guidelines* ($\mu\text{g}/\text{m}^3$)	Maximum Conc. ($\mu\text{g}/\text{m}^3$)	% of Guideline**	Max. Boundary Conc. ($\mu\text{g}/\text{m}^3$)	% of Guideline**	Long- Term	Long- Term	Long- Term
1,2-Dichloroethene	540-59-0	200	1881		10 ⁻⁴	10 ⁻⁶	RfC	Short-term	Annual	24-Hr	24-Hr	24-Hr
								2900-7900	79-108	0.51	0.09	<1
									<1	0.49	0.05	<1
										<1		<1

* Range of values represent upper and lower bound state guideline levels as found in NATICH.

** Based on arithmetic average of upper and lower bound guideline values.

*** Data from both within and above the certified range are summarized here.

— Not analyzed during these phases

Legend: TLV = Threshold Limit Value

RBAC* = Risk-based air concentration for long-term (lifetime) residential exposures. RBACs for carcinogens are derived from unit risks reported in EPA's Integrated Risk Information System (IRIS) database or EPA's Health Effects Assessment Summary Tables (HEAST 1992). RBACs for noncarcinogens are Reference Concentrations (RfCs) reported in the same documents.

TABLE 4.6-14
COMPARISON OF EPA AIR TOXIC STUDY AND RMA RESULTS FOR VOCs

Analyte	Maximum Concentration for Denver Study* ($\mu\text{g}/\text{m}^3$)	Maximum Concentration At RMA ($\mu\text{g}/\text{m}^3$) (Phases 1-3)	Maximum Concentration At RMA ($\mu\text{g}/\text{m}^3$) (Phase 4)	Maximum Concentration At RMA ($\mu\text{g}/\text{m}^3$) (Phase 5)
1,2-Dichloroethane	49	4	0.2	0.2
1,1,1-Trichloroethane	44	73	7.2	5.8
Carbon Tetrachloride	3	10	1.9	1.8
Trichloroethene	4	40	0.5	0.2
Tetrachloroethene	14	24	6.3	2.3
Benzene	83	44	7.5	9.1
Toluene	294	158	16.9	10.8
Ethylbenzene	22	13	5.3	2.2
o-Xylene	13	8	5.9	--
m- and p-Xylene (Total Xylenes)	252	50	9.5	10.1
Chlorobenzene	83	3	0.1	0.1

*Source: U.S. EPA. 1989. Report on the Air Toxics Monitoring Program for the Denver Metropolitan Area. Integrated Environmental Management Project. Report One, Data Summary. Region VIII, Denver, Colorado.

-- Not analyzed during this phase

TABLE 4.6-15

AMBIENT VOLATILE ORGANIC COMPOUNDS (VOC) CONCENTRATIONS FROM VARIOUS STUDIES

Target Name	1987 EPA NMOC, Study Means $\mu\text{g}/\text{m}^3$	1988 EPA UATMP Mean $\mu\text{g}/\text{m}^3$	FY91 CMP* Basin F Mean $\mu\text{g}/\text{m}^3$	FY91 CMP* Basin A Mean $\mu\text{g}/\text{m}^3$	FY91 CMP* S ₃ Plants Mean $\mu\text{g}/\text{m}^3$	FY91 CMP* Perimeter Mean $\mu\text{g}/\text{m}^3$
1,1,1-Trichloroethane	18.6	6.7	11.74	—	11.264	1.241
1,1,2-Trichloroethane	—	3.0	ND	—	ND	ND
1,1-Dichloroethane	13.7	2.0	0.021	—	ND	ND
1,2-Dichloroethane	25.1	8.1	0.036	—	ND	0.024
Benzene	6.5	5.2	1.220	—	1.444	1.476
Bicycloheptadiene	—	—	0.026	—	0.168	ND
Carbon Tetrachloride	—	2.1	0.501	—	0.257	0.396
Chlorobenzene	7.4	3.0	0.023	—	ND	0.021
Chloroform	—	30.8	0.242	—	0.066	0.172
Dicyclopentadiene	—	—	ND	—	0.310	ND
Dimethyl disulfide	—	—	ND	—	ND	ND
Ethylibenzene	—	7.0	0.396	—	0.498	0.504
Methylene Chloride	78.4	18.1	1.553	—	—	1.282
Methylisobutyl Ketone	—	—	ND	—	ND	ND
m-Xylene	59.1	18.7	—	—	—	—
N-Nitrosodimethylamine	—	—	—	—	—	—
o-Xylene (12DMB)	7.4	5.7	—	—	—	—
p-Xylene	59.1	18.9	1.658*	—	2.574*	2.443*
Tetrachloroethylene	34.1	13.1	0.525	—	0.686	0.527
Toluene	32.0	16.4	2.674	—	3.612	2.686
Trans-1,2-Dichloroethylene	9.7	4.4	—	—	—	—
Trichloroethylene	20.8	10.4	—	—	ND	0.029

Source: U.S. EPA, 1988. 1987 Nonmethane Organic Compound and Air Toxics Monitoring Program, Final Report, Vol. II, "Toxic Species." EPA-450/4-88-012. Research Triangle Park, North Carolina: U.S. EPA Office of Research and Development.

* Data from both within and above the certified range are reported here.

Legend: NMOC = Nonmethane Organic Compound

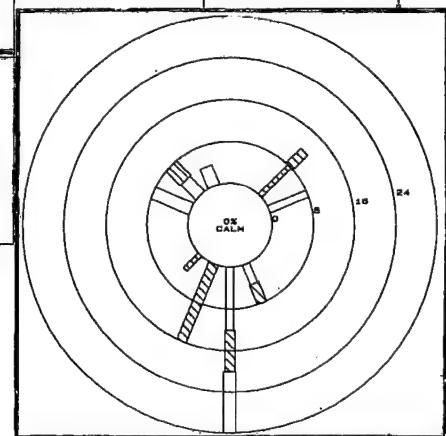
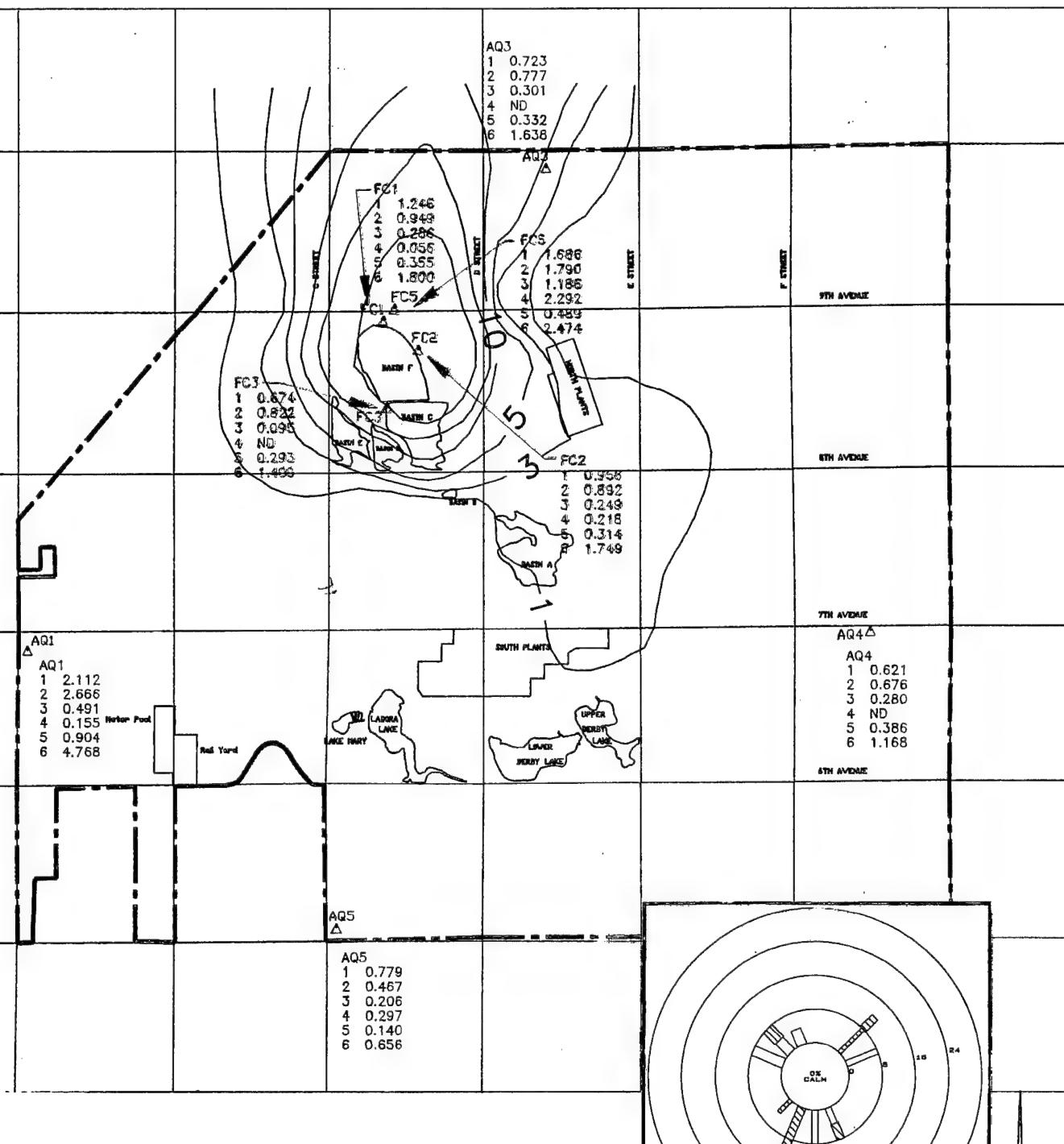
UATMP = Urban Air Toxics Monitoring Program

— Not analyzed during this phase

ND Not-detectable
Monitoring result based on total xylenes

TABLE 4.6-16
SUMMARY OF NONTARGET VOCs

Chemical Grouping	Number of Detections	24-Hour Maximum	Mean	Minimum
Alkanes	21	1400	222	70
Alkenes	2	230	190	150
Cyclic Alkanes	7	700	418	56
Aromatic hydrocarbons (arenes)	7	200	116	49
Ketone	1	180	180	180



QI2 A Comprehensive Monitoring Location

FC2 A CMP FC Sites (Formerly IRA-F)

- 1 = 1,1,1-Trichlorethane
- 2 = Benzene
- 3 = Carbon Tetrachloride
- 4 = Chloroform
- 5 = Ethylbenzene
- 6 = Xylene
- ND = Non-Detectable

24 Hour Maximum (ug/m³)

Source: Basin F



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

**VOC Results and x/Q Dispersion for 06/12/91
CMP Air Quality Data Rocky Mountain Arsenal**

U.S. Program Manager

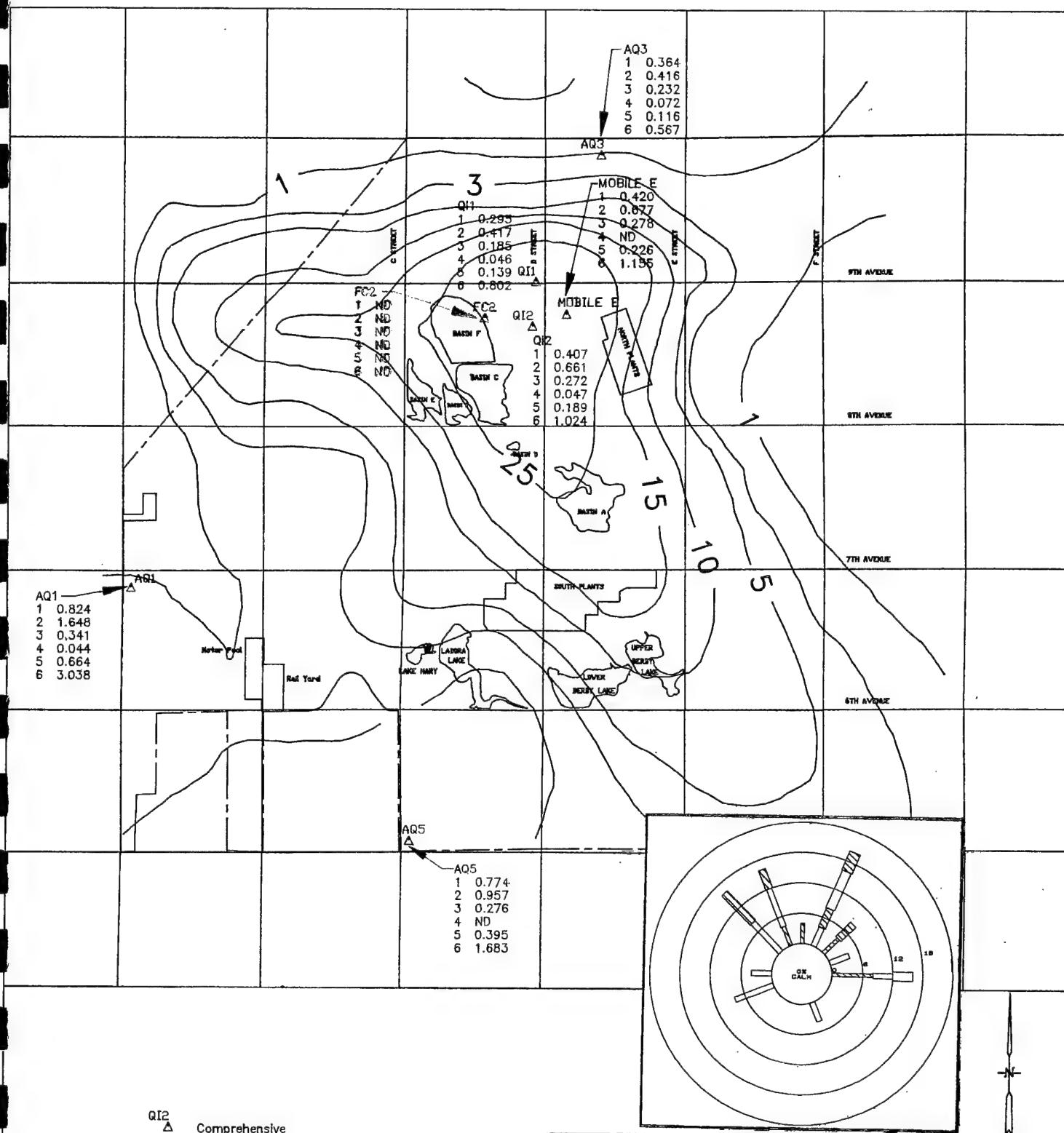
Rocky Mountain Arsenal

DRWN BY : dwb DATE : 5/5/92

PROJECT NO: 22787E FIG. NO:

CHKD BY : DATE :

4.6-1



QI2 ▲ Comprehensive Monitoring Location

FC2
Δ CMP FC Sites
(Formerly IRA-F)

1 = 1,1,1-Trichloroethane
 2 = Benzene
 3 = Carbon Tetrachloride
 4 = Chloroform
 5 = Ethylbenzene
 6 = Xylene
 ND = Non-Detectable

24 Hour Maximum (ug/m³)

Source: Quench Incinerator

A horizontal scale bar with numerical markings at 5000, 0, 5000, and 10000. The word "SCALE" is written above the left end, and "Feet" is written below the right end.

ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

VOC Results and x/Q Dispersion for 06/20/91
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb DATE : 5/5/92

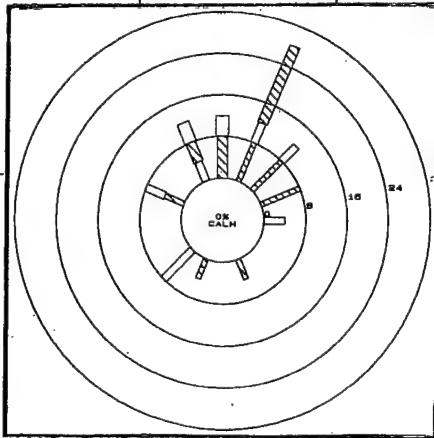
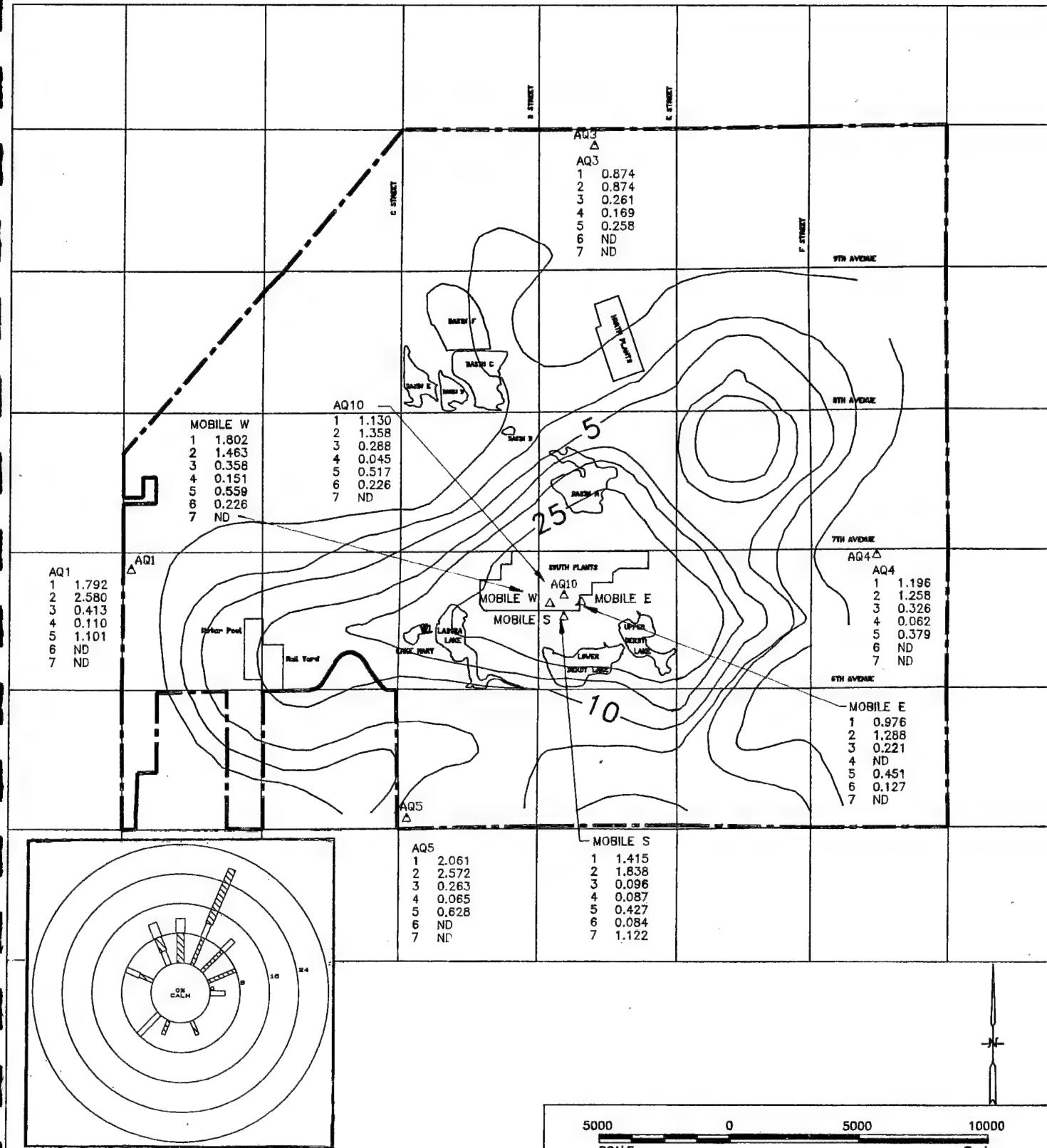
CHKD BY : DATE :

PROJECT NO:

22787E

FIG. NO.:

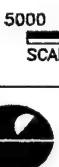
4.6-2



LEGEND

- AQ5** Comprehensive Monitoring Location
- 1 = 1,1,1 Trichloroethane
- 2 = Benzene
- 3 = Carbon Tetrachloride
- 4 = Chloroform
- 5 = Ethylbenzene
- 6 = Bicycloheptadiene
- 7 = Dicyclopentadiene
- ND = Non-Detectable

Source: South Plants Subdrain



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

VOC Results and x/Q Dispersion for 06/26/91
CMP Air Quality Data Rocky Mountain Arsenal

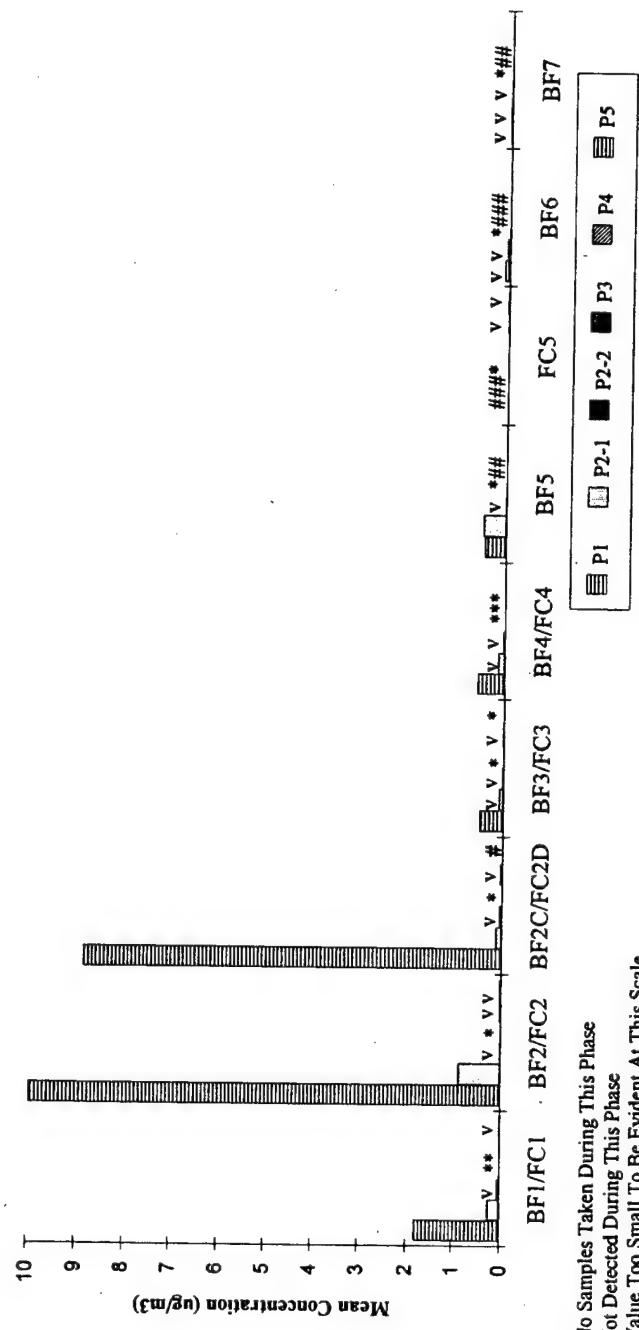
U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	dwb	DATE : 5/5/92	PROJECT NO:	FIG. NO :
CHKD BY :	.	DATE :	22787E	4.6-3

5000 0 5000 10000
SCALE Feet

Bicycloheptadiene Results by Phase



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

BICYCLOHEPTADIENE RESULTS BY PHASE

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :

DATE :

PROJECT NO:

FIG. NO :

CHKD BY :

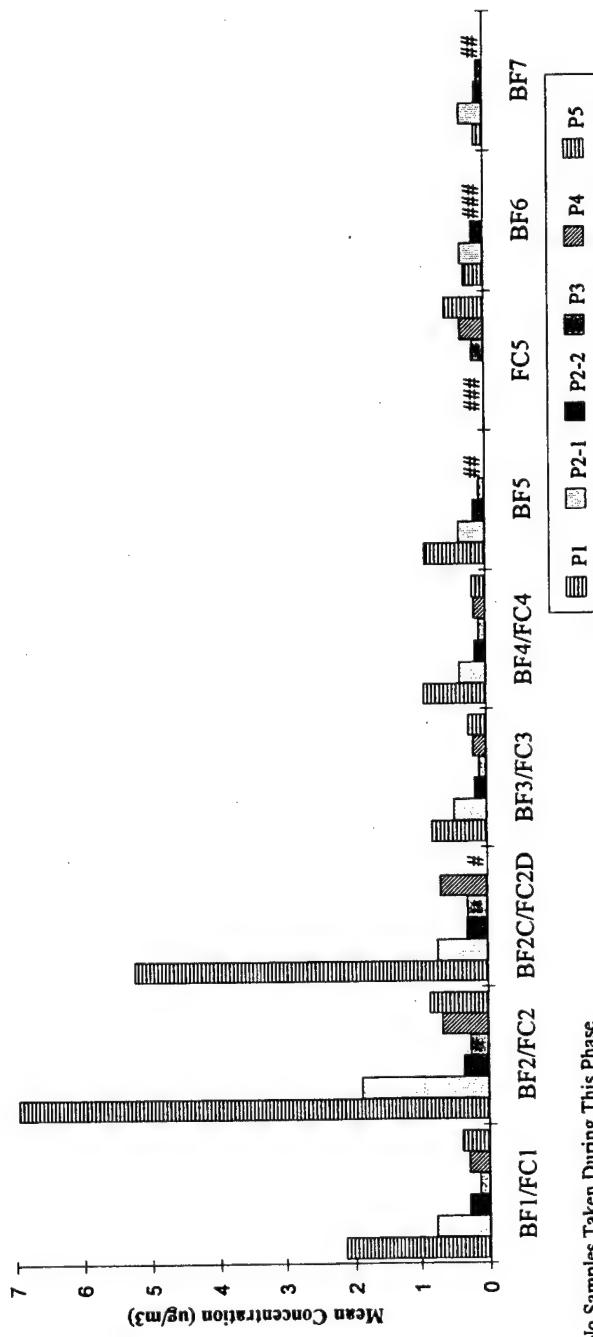
DATE :

22787E

4.6-4

CMP AR FY91

Chloroform Results by Phase



No Samples Taken During This Phase

* Not Detected During This Phase



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

CHLOROFORM RESULTS BY PHASE

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :

DATE :

PROJECT NO:

FIG. NO :

CHKD BY :

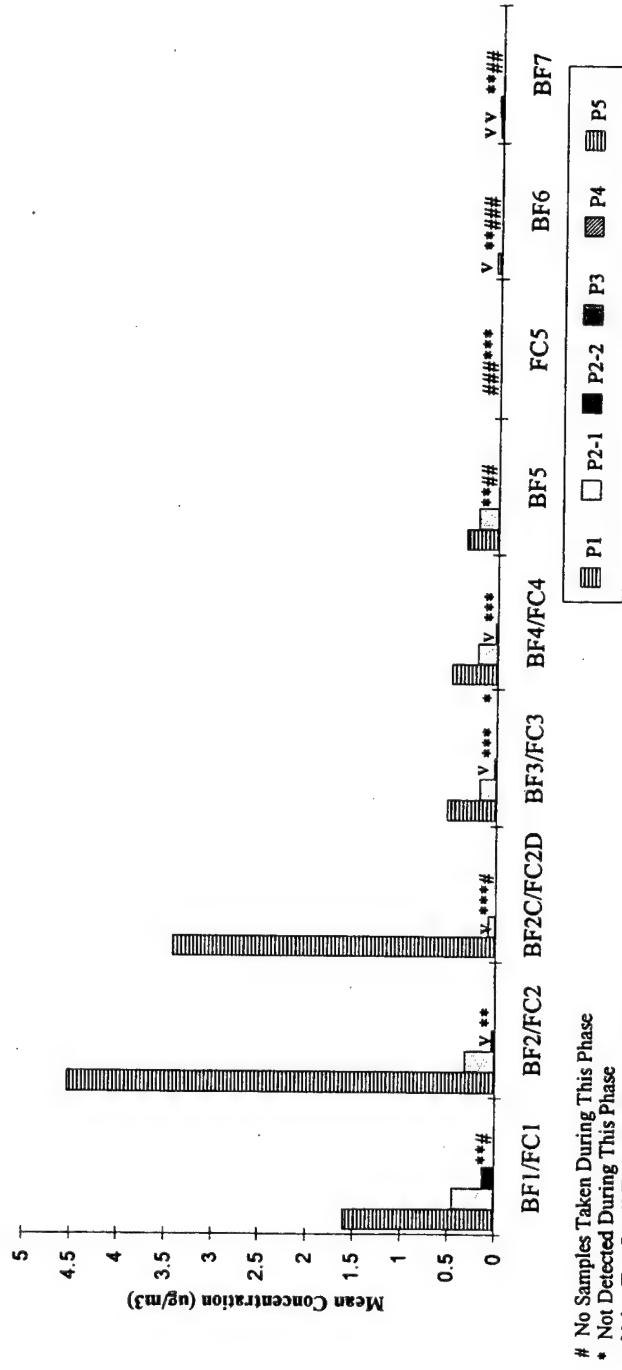
DATE :

22787E

4.6-5

CMP AR FY91

Dicyclopentadiene Results by Phase



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

DICYCLOPENTADIENE RESULTS BY PHASE

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :

DATE :

PROJECT NO:

FIG. NO :

CHKD BY :

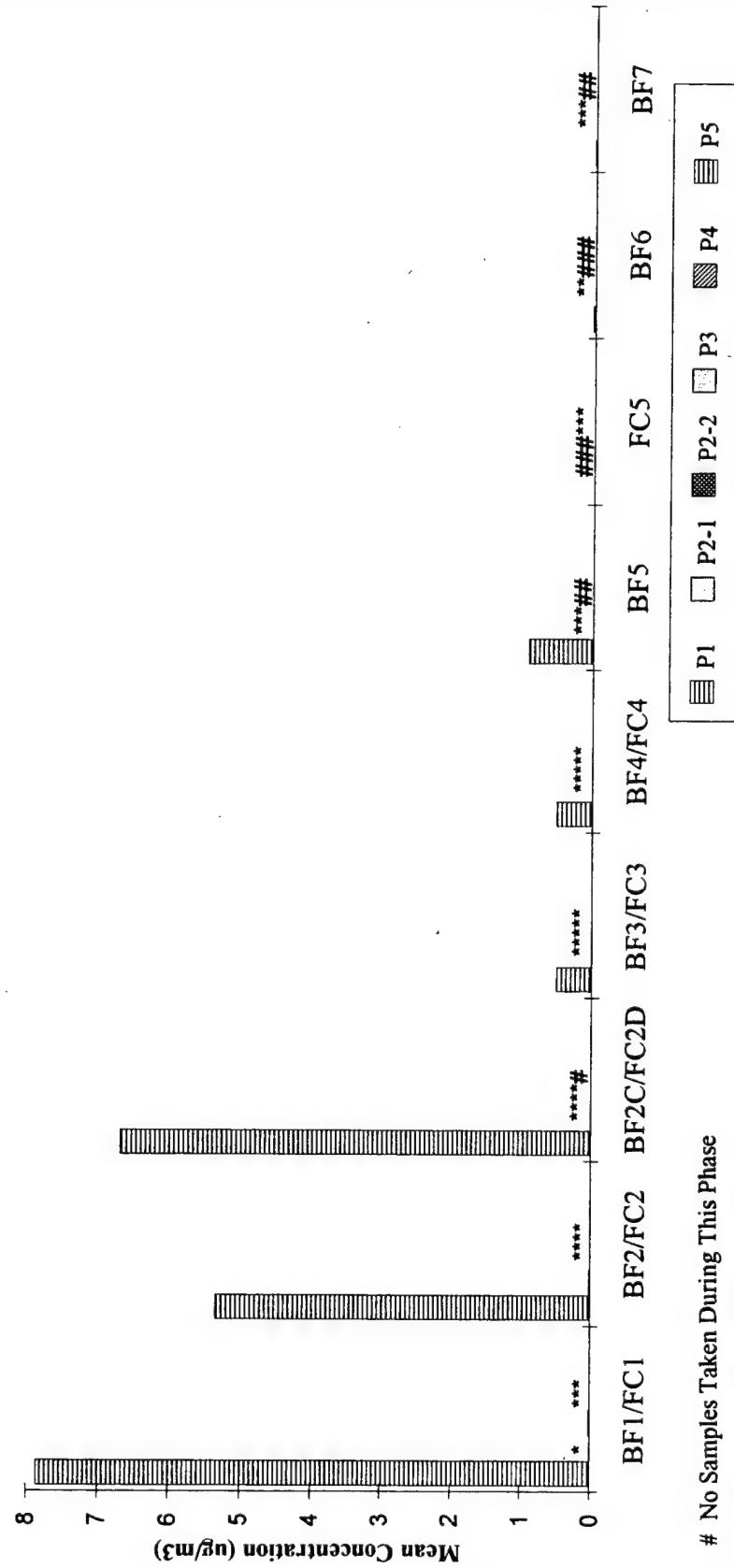
DATE :

22787E

4.6-6

CMP AR FY91

Dimethyldisulfide Results by Phase



Woodward-Clyde Consultants
 ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

DIMETHYL DISULFIDE RESULTS BY PHASE

U.S. Program Manager

Rocky Mountain Arsenal

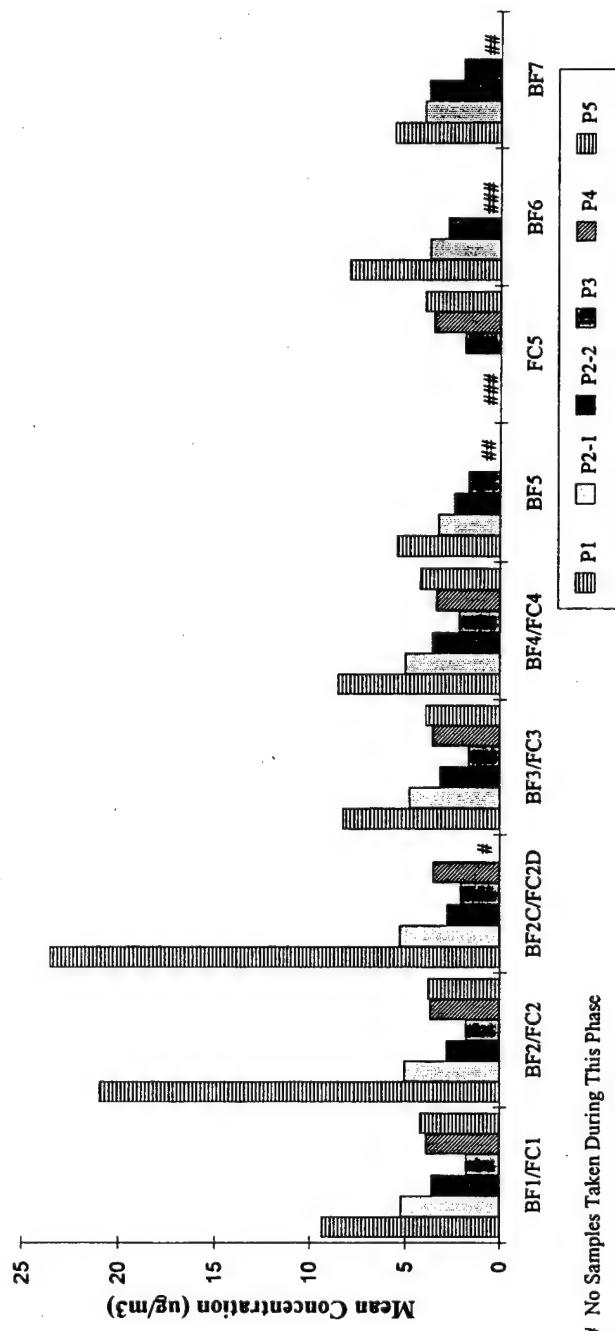
DRWN BY : DATE :

PROJECT NO. FIG. NO. :

CHKD BY : DATE :

22787E 4.6-7

Toluene Results by Phase



No Samples Taken During This Phase

* Not Detected During This Phase



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

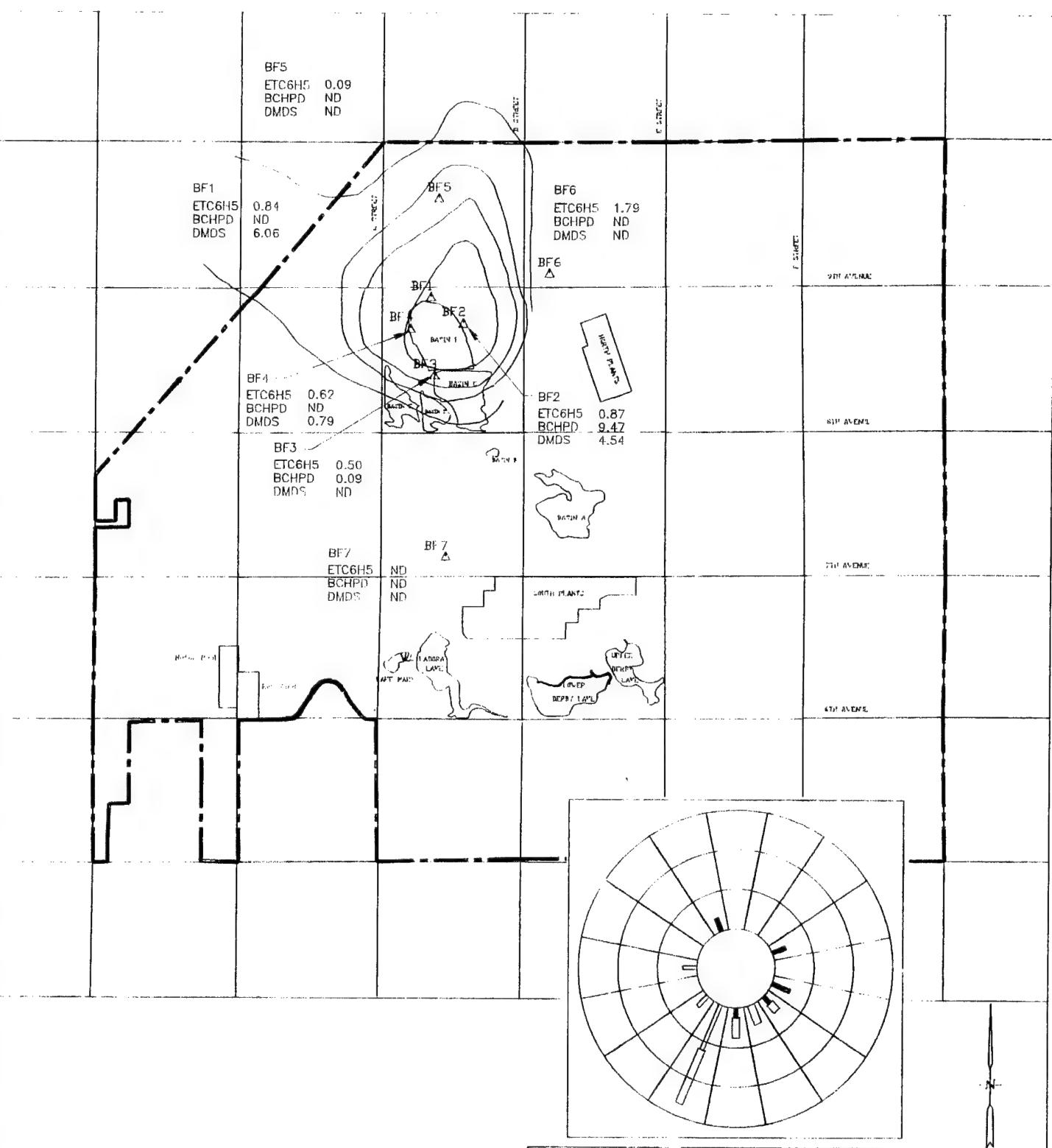
TOLUENE RESULTS BY PHASE

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	DATE :	PROJECT NO:	FIG. NO :
CHKD BY :	DATE :	22787E	4.6-8

CMP AR FY91



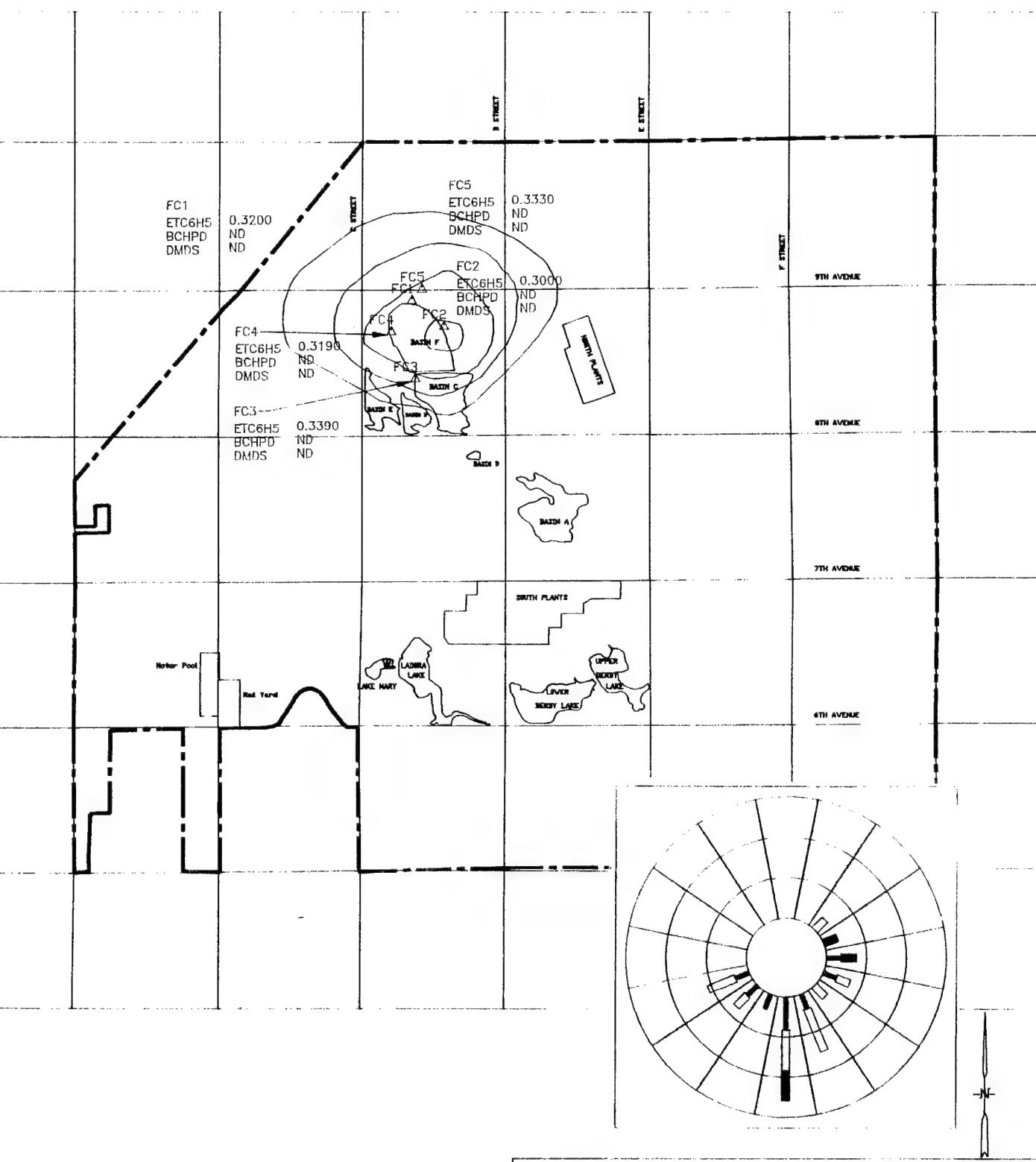
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

**x/Q Dispersion and Basin F VOCs For 8/12/88
Basin F Air Quality Data**

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY	dwb	DATE	5/5/92	PROJECT NO:	22787E
CHKD BY		DATE			4.6-9



LEGEND

FC3 IRA-F Monitoring Location

ETC6H5 ETHYLBENZENE
 BCHPD BICYCLOHEPTADIENE
 DMDS DIMETHYLDISULFIDE

ND = Non-Detectable

(ug/m³)

5000
SCALE

Woodward-Clyde Consultants

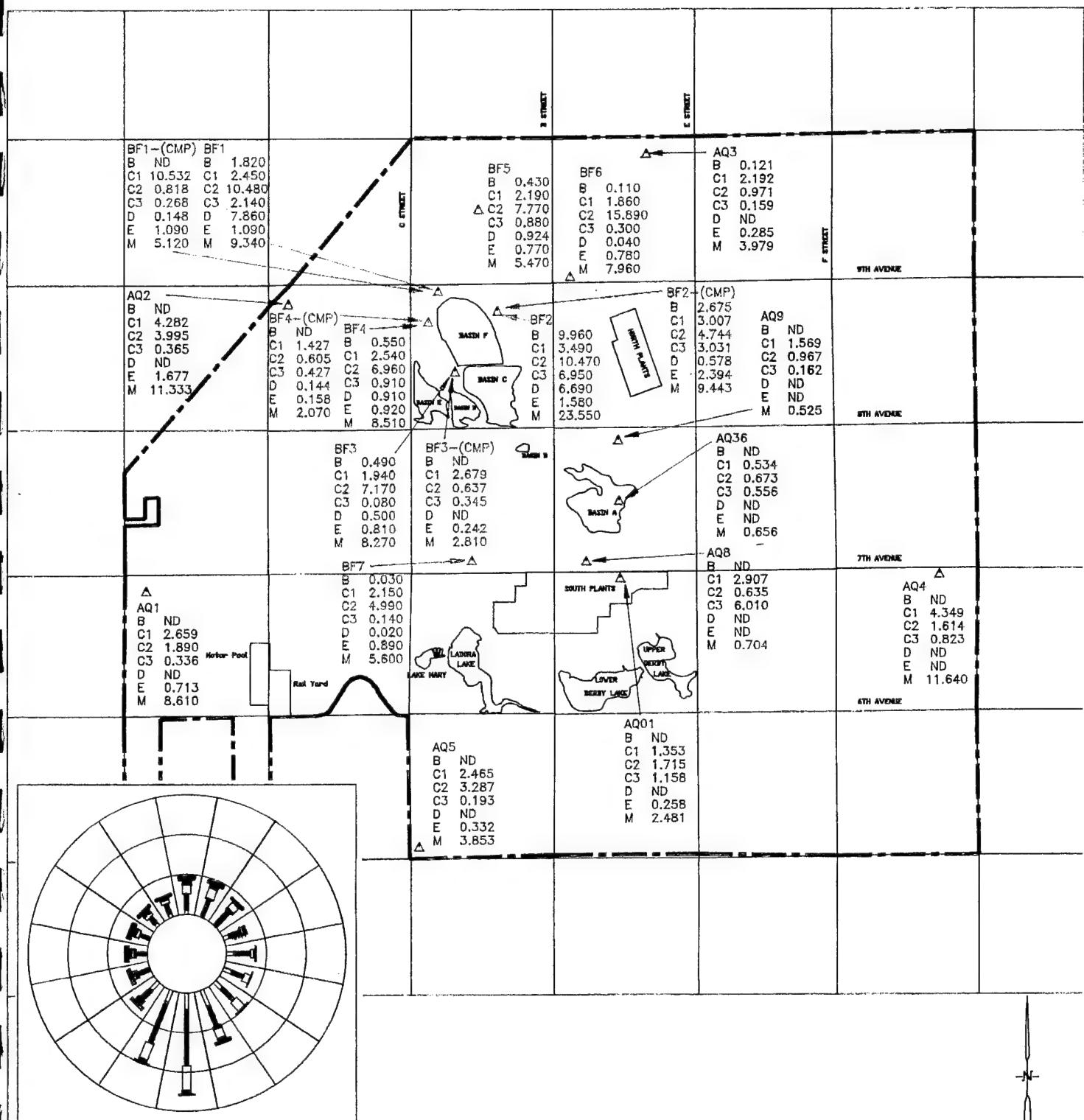
x/Q Dispersion and IRA-F VOCs For 7/28/90
IRA-F Air Quality Data

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb DATE : 5/5/92

PROJECT NO: FIG. NO :
22787E 4.6-10



LEGEND

- AQ5 Comprehensive Monitoring Location
- BF1 BASIN F Monitoring Location
- B = Bicycloheptadiene
C1 = Benzene
C2 = Methylene Chloride
C3 = Chloroform
D = Dimethyl Disulfide
E = Ethylbenzene
M = Toluene

Annual Average (ug/m³)



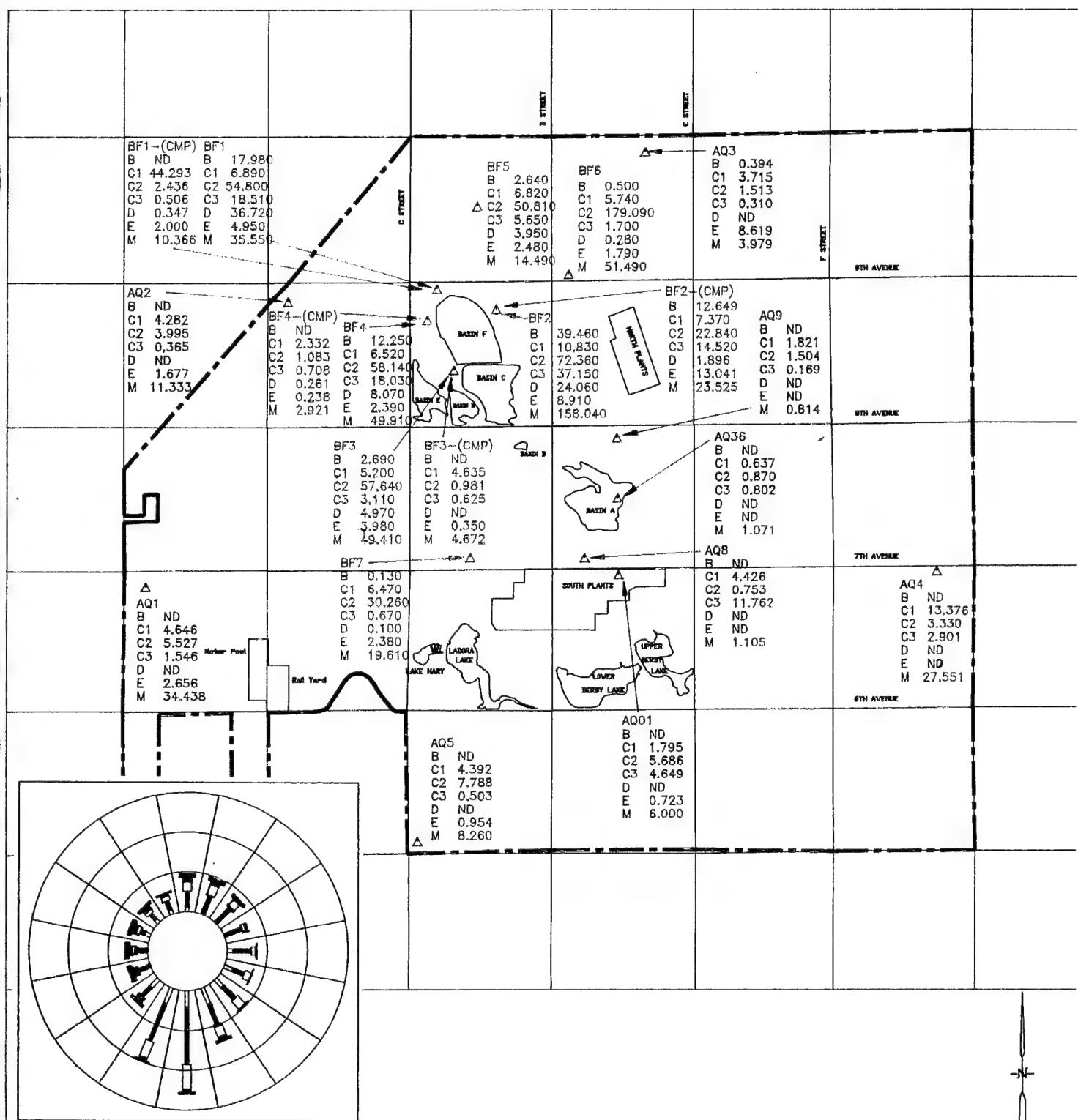
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

Composite VOC Analysis for Phase 1 CMP Air Quality Data

U.S. Program Manager

Rocky Mountain Arsenal

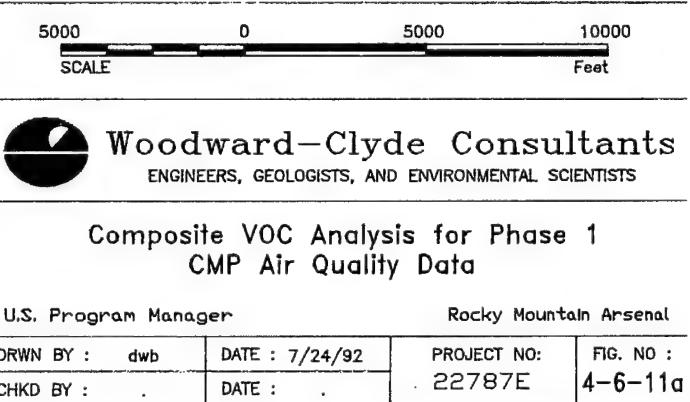
DRWN BY :	dwb	DATE : 7/24/92	PROJECT NO:	FIG. NO :
CHKD BY :	.	DATE :	22787E	4.6-11

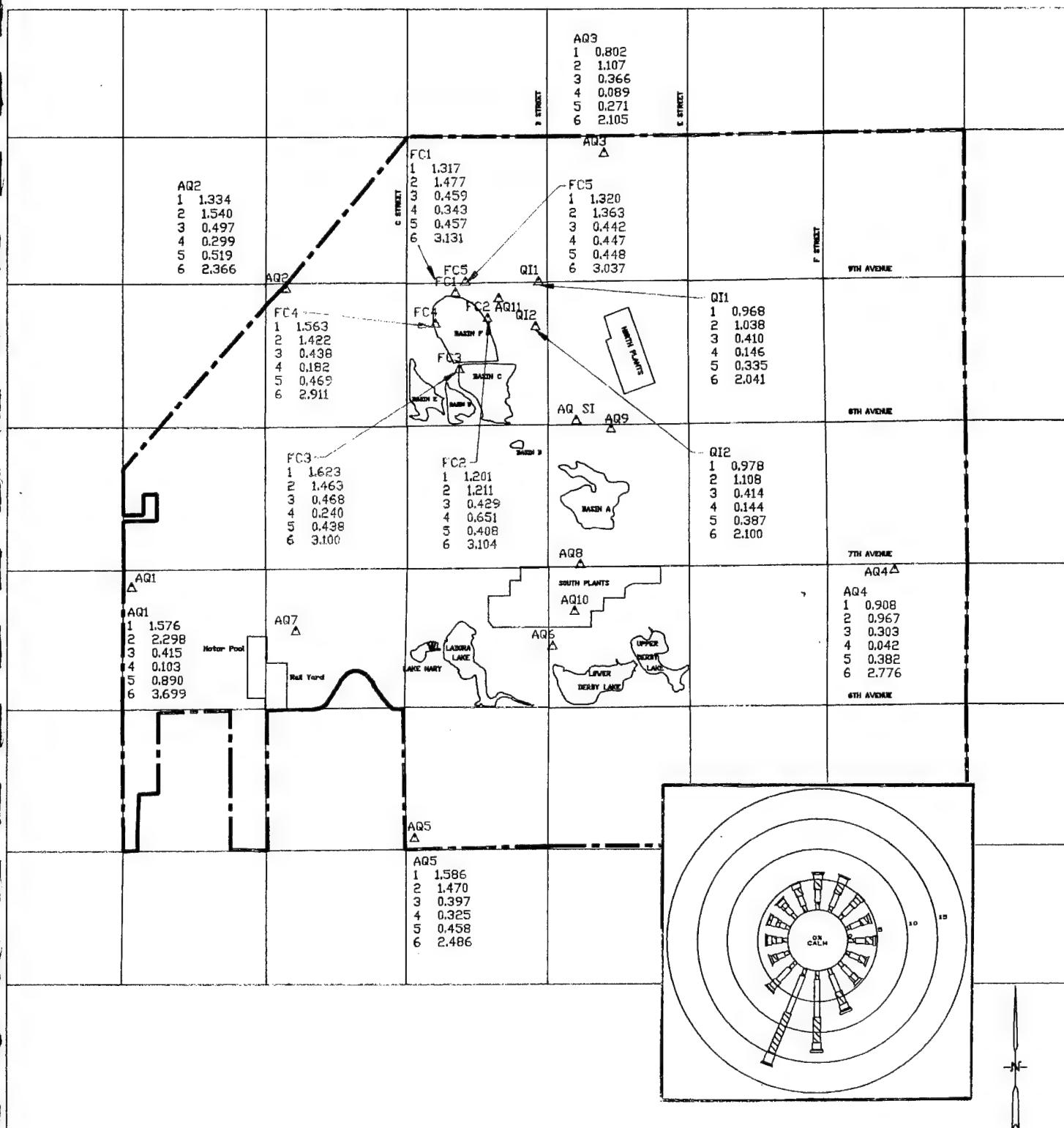


LEGEND

- BF3** Comprehensive Monitoring Location
- AQ8** Basin F Monitoring Location
- B** = Bicycloheptadiene
- C1** = Benzene
- C2** = Methylene Chloride
- C3** = Chloroform
- D** = Dimethyl Disulfide
- E** = Ethylbenzene
- M** = Toluene

24 Hr Maximum (ug/m³)





L E G E N D

FC3 CMP FC Sites (Formerly IRA-F)
AQ5 Comprehensive Monitoring Location

1 1,1,1 Trichloroethane
2 Benzene
3 Carbon Tetrachloride
4 Chloroform
5 Ethylbenzene

Annual Average ($\mu\text{g}/\text{m}^3$)



Woodward-Clyde Consultants

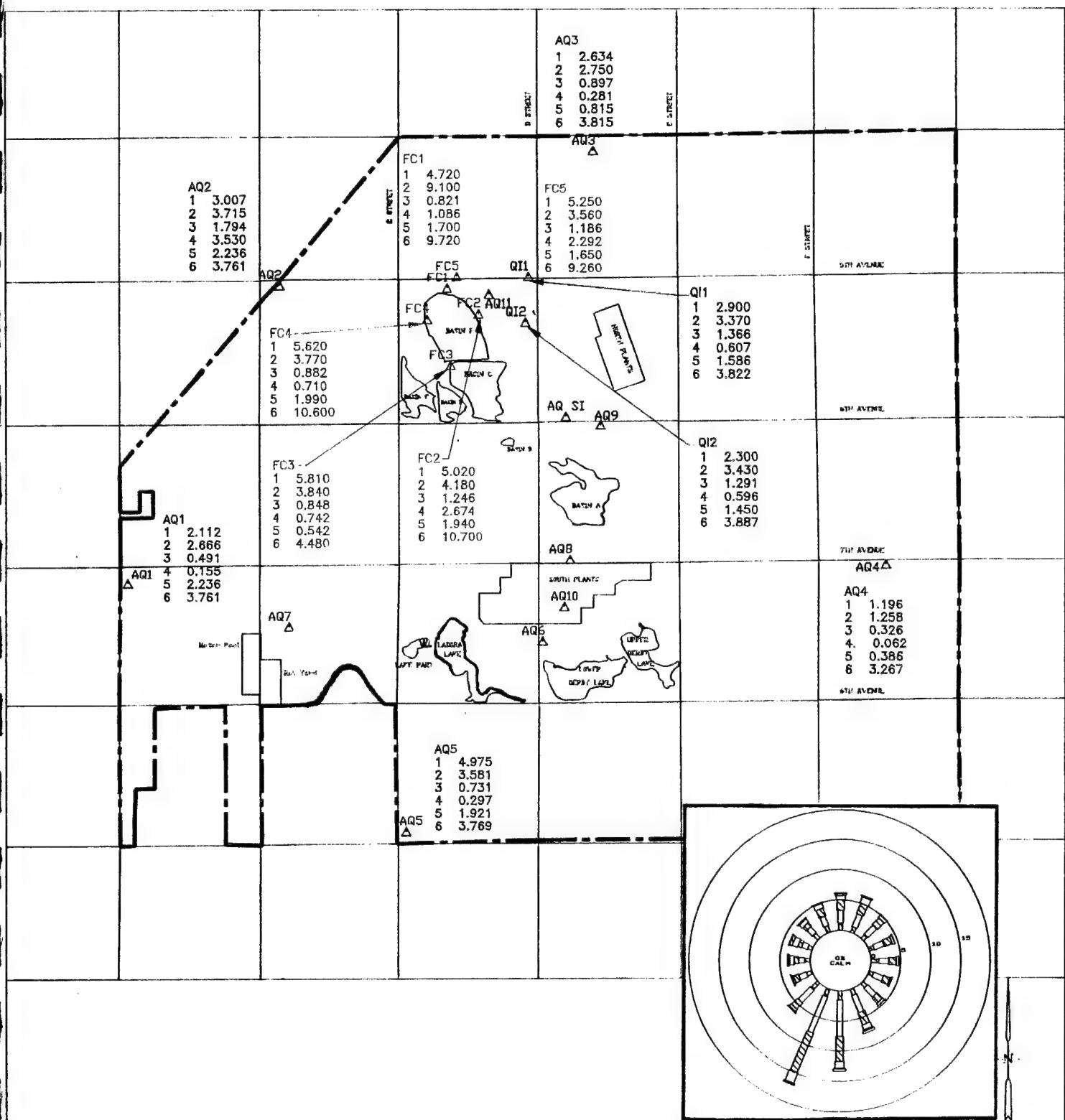
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

Composite VOC Analysis for Phase 5 CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

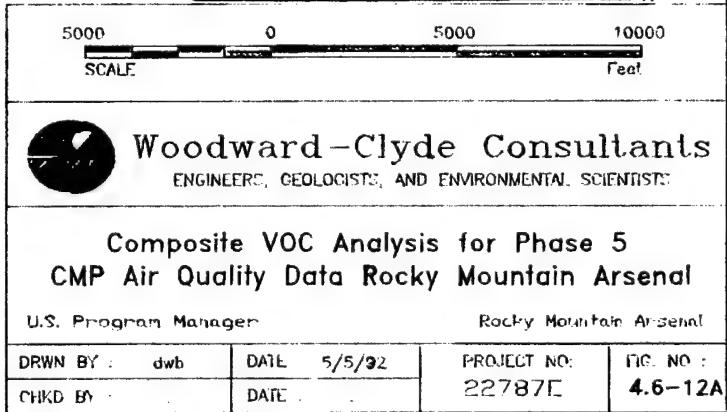
DRWN BY : dwb	DATE : 5/5/92	PROJECT NO:	FIG. NO :
CHKD BY : -	DATE : -	22787E	4.6-12

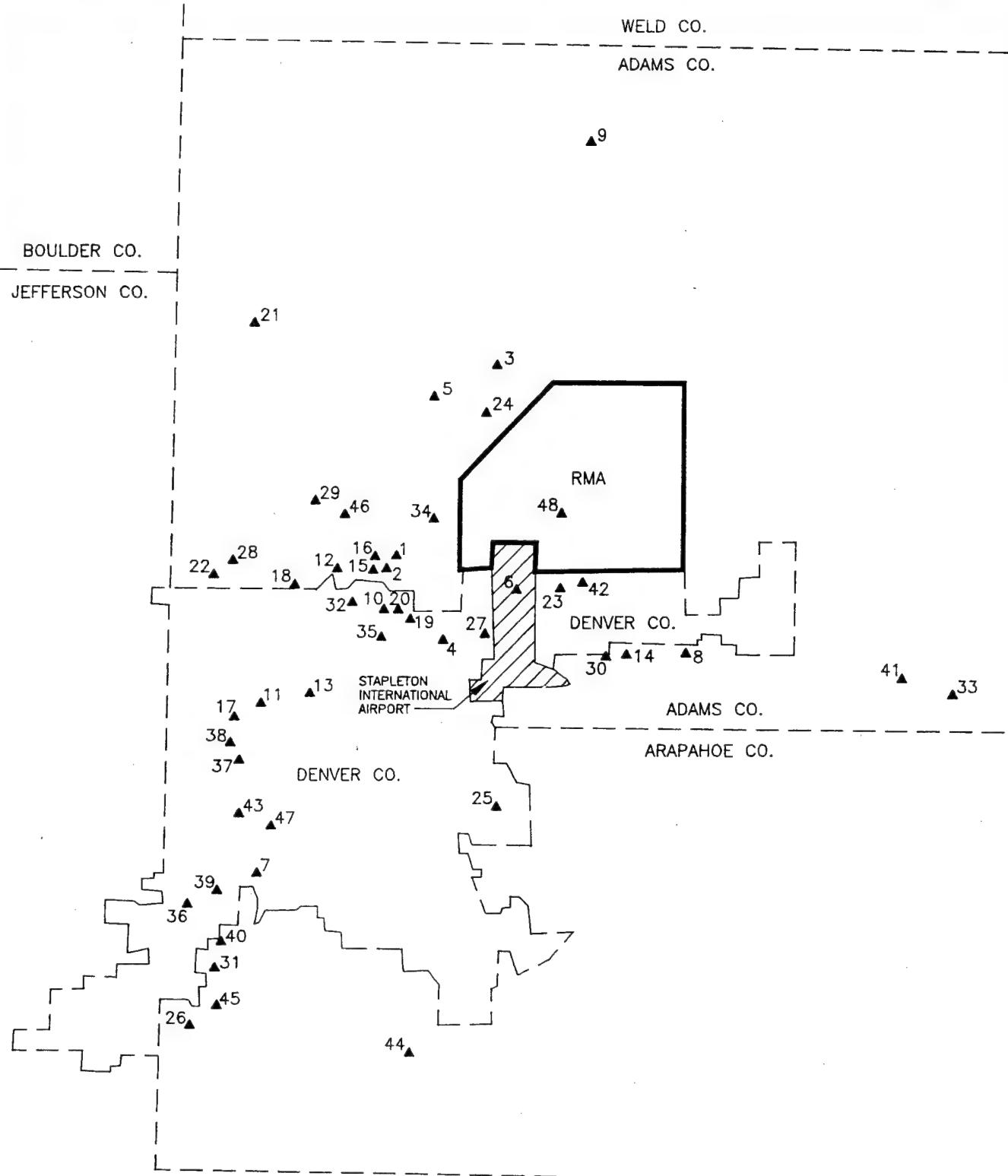


LEGEND

- FC3 CMP FC Sites (Formerly IRA-F)
- AQ5 Comprehensive Monitoring Location
- 1 1,1,1 Trichloroethane
- 2 Benzene
- 3 Carbon Tetrachloride
- 4 Chloroform
- 5 Ethylbenzene
- 6 Toluene

24 Hour Maximum ($\mu\text{g}/\text{m}^3$)



LEGEND▲³⁰ APPROXIMATE LOCATION OF SOURCE

— — APPROXIMATE COUNTY LINE



0 2 4
SCALE IN MILES

27874613

Job No. :	22787E
Prepared by :	G.E.R.
Date :	8/21/92

VOC SOURCES WITH EMISSIONS
OF 25 TPY OR
MORE IN RMA VICINITY

4.7 ORGANOCHLORINE PESTICIDES (OCPs)

4.7.1 Monitoring, Analysis and Reporting Strategies

Organochlorine pesticide (OCP) monitoring, which provides measurements of pesticide levels at the RMA interior and perimeter sites, are described in this section. During FY91, routine and high event OCP monitoring replaced seasonal and high event semi-volatile organic compound (SVOC) pesticide monitoring as the principal method of measuring pesticide levels at the RMA. This change was the result of experience and analysis of several different methods to determine the most effective means of collecting and measuring pesticides. As prescribed in the CMP Technical Plan, the F-7 GC/MS method was initially used for analyses of SVOC and the H-7 GC/ECD method was used for the analyses of OCPs. During the FY88 Basin F remedial period, the H-7 GC/ECD method was also used to confirm low levels of SVOC pesticides. The H-7 method is approximately 100 times more sensitive to pesticides than the F-7 method, and proved to be more appropriate for monitoring SVOC pesticide levels at RMA. In FY88, there were only minimal detections of SVOC under the F-7 method, and in FY89 and FY90, there were no detections under this method, consequently, the more sensitive H-7 method identified pesticides for both of these periods for the Basin F and IRA-F monitoring programs. In FY90, methods CM02 and CM03, more sensitive versions of F-7, were employed to analyze pesticides during CMP high event episodes. Finally, the CM03 method for OCP was used exclusively for pesticide monitoring at RMA during FY91.

The CMP FY90 monitoring programs (CMP and Basin F sites) were concluded on September 30, 1990. Initially, only the Basin F (or IRA-F) program was extended for FY91. The extension for the CMP perimeter sites was not authorized until January 24, 1991. Therefore, there are no data available for the CMP perimeter sites from October 2, 1990 to January 18, 1991.

As discussed in Section 4.6.1 VOC Monitoring, Analysis and Reporting Strategies, the CMP, Basin F and IRA-F monitoring programs were integrated into a single program after January 24, 1991. Thus, the Basin F monitoring program for the period October 2, 1990 to January 18, 1991 will be referred to in this report as Stage 1 of Phase 5, and the

period from January 24, 1991 to the end of FY91 (September 30, 1991) will be referred to as Stage 2 of Phase 5.

In FY90, routine OCP monitoring was limited to three RMA perimeter sites (AQ1, AQ3, and AQ5) and was performed on an every 12th day schedule. OCP monitoring was modified in FY91 to routinely measure OCPs at eight fixed sites (AQ2, AQ3, AQ5, FC1, FC2, FC5, QI1, and QI2) on an every sixth day schedule, and at a ninth fixed site (AQ1) every 12th day. OCP sampling at two additional fixed Basin F sites (FC3 and FC4) was initially performed on an every sixth day schedule until March 31, 1991, when sampling frequency was reduced to once per month. A collocated sampler was also placed at the FC1 site (designated FC1C) to provide quality assurance data for the monitoring program.

A summary of the fixed station program and the data recovery for the OCP monitoring is given in Table 4.7-1. The cumulative data recovery for all OCP monitoring sites for FY91 exceeded the 80 percent (i.e., 89 percent) criterion specified for air quality pollutant monitoring for a typical PSD program.

In addition to the routine monitoring at these 11 sites, three OCP high events periods were evaluated utilizing several of the fixed sampling sites and several mobile sites surrounding Basin F, the quench incinerator construction site, and the South Plants subdrain area. The dates, periods, and samplers used for the three high event periods is shown in Table 4.7-2.

4.7.2 CMP FY91 OCP Monitoring Results

Table 4.7-3 presents a summary of the FY91 OCP monitoring results for the fixed perimeter CMP stations at the RMA. As previously mentioned, sampling at these locations was performed from January 24, 1991 through the end of FY91. Table 4.7-4 summarizes the FY91 OCP monitoring results for the Basin F stations within the RMA. This table shows both the annual average and 24-hour maximum concentrations of each OCP at each monitoring site. Table 4.7-4 distinguishes between the data collected during Stage 1 (October 2, 1990 through January 18, 1991) and Stage 2 (January 24, 1991 through September 30, 1991) of Phase 5. Table 4.7-5 presents a summary of FY91 OCP

monitoring results during the three high event periods. The sampling was performed at fixed (FC1, FC2, FC3, FC5, QI1, and QI2) and mobile (AQ01, AQ10, and AQ25) sites. The AQ01 site is a combination of three mobile locations (Mobile E, Mobile S, and Mobile W).

Six-day, 12-day, and monthly sampling was conducted at 11 monitoring locations throughout FY91. Nine of these monitor locations were used previously for OCP and SVOC monitoring in Phases 1 through 4. Two new monitor sites were located and operated in the vicinity of the submerged quench incinerator, QI1 and QI2, from March 31, 1991 through the end of FY91. The three high event sampling periods at the fixed and mobile sites were conducted during the summer season when conditions met the high event sampling criteria.

Measured concentrations during FY91 were generally comparable or lower than concentrations observed during FY88, FY89, or FY90 with the exception of chlordane. In addition, concentrations of aldrin and dieldrin were slightly higher when high event sampling locations are included.

The highest maximum 24-hour concentration of aldrin during FY91 occurred at the AQ10 site during the June 26-27, 1991 high event period. The aldrin concentration of $0.0338 \mu\text{g}/\text{m}^3$ during this period was slightly higher than the $0.0300 \mu\text{g}/\text{m}^3$ highest maximum 24-hour aldrin concentration at the FC2 site in FY90. By comparison, the highest maximum 24-hour concentration at the FC2 site in FY91 was $0.00634 \mu\text{g}/\text{m}^3$. This concentration was the second-highest maximum 24-hour aldrin concentration in FY91. The Phase 4 and Phase 5 aldrin levels were above Phase 2-Stage 2, Phase 3 and Phase 5 post-remedial periods, but well below Phase 1 and Phase 2-Stage 1 remediation periods.

FY91 chlordane impact levels were generally higher than comparable post-remedial periods. A trend of increasing chlordane levels began in Phase 2-Stage 2 and has continued through Phase 5. To explain this upward trend, a comparison of the monitoring data was performed for the perimeter sites, the Basin F & Quench Incinerator sites, and sampling sites during the high event periods. The comparison shows that chlordane impacts at perimeter monitoring sites (AQ1, AQ2, AQ3, and AQ5)

have increased steadily from Phase 1 to Phase 5. Basin F (FC) and Quench Incinerator (QI) site data shows that elevated chlordane levels occurred during remediation activities (Phase 2-Stage 1), dropped significantly after remediation was complete (Phase 2-Stage 2), and has risen steadily during the subsequent phases. Finally, a comparison of routine and high event sampling data indicates that elevated chlordane concentrations are not correlated to high event periods. These comparisons would indicate that the RMA is most likely not the source of the chlordane in the region and the chlordane is being transported in from offsite.

Dieldrin concentrations during FY91 were slightly higher than during most other post-remedial phases but well below Phase 1 remediation levels. The highest maximum 24-hour dieldrin concentration occurred at the mobile stations (AQ01) located near the South Plants during the June 26-27, 1991 high event period. The dieldrin concentration during this period was $0.0618 \mu\text{g}/\text{m}^3$. This concentration is comparable to Phase 2 through Phase 4 concentrations ranging from $0.0340 \mu\text{g}/\text{m}^3$ to $0.0720 \mu\text{g}/\text{m}^3$.

Monitoring results for endrin, isodrin, PPDDE, and PPDDT show comparable concentrations for all post-remedial phases. The concentrations in FY91 were not influenced by specific weather conditions associated with high event periods or construction related activities.

4.7.2.1 Basin F High Event Period, June 12-13, 1991

Monitoring for OCPs was performed during this event at four fixed sites surrounding the remediated Basin F area (FC1, FC2, FC3, and FC5) from 1200 MST, June 12 to 1200 MST, June 13, 1991. Figure 4.7-1 presents site locations, sampling results for the selected pesticides, a wind rose depicting the wind flow distribution during the sampling period, and the resultant dispersion pattern assuming that Basin F was the primary emission source potentially contributing to ambient OCPs. The maximum temperature during this sampling period was 82°F, with predominant south and south-southwesterly winds.

Assuming that the remediated Basin F area was the primary emission source of OCPs potentially contributing to ambient concentrations, the dispersion pattern indicates higher

expected impacts in the immediate vicinity of Basin F and along a north to north-northeasterly axis from Basin F. The observed data supported this expectation for all OCPs except chlordane. The highest levels of dieldrin, $0.0099 \mu\text{g}/\text{m}^3$, and endrin, $0.0011 \mu\text{g}/\text{m}^3$, occurred at FC1 and FC2, respectively. These sites are located on the northern and northeastern boundary of Basin F. The dieldrin and endrin levels at the FC3 site located on the southern boundary of Basin F were $0.0028 \mu\text{g}/\text{m}^3$ and non-detectable, respectively. The maximum chlordane concentration, $0.0090 \mu\text{g}/\text{m}^3$, occurred at FC2 site which on the northeastern boundary of Basin F. However, chlordane concentrations at FC1, $0.0028 \mu\text{g}/\text{m}^3$, and FC5, $0.0024 \mu\text{g}/\text{m}^3$, were lower than the chlordane concentration at the FC3 site, $0.0041 \mu\text{g}/\text{m}^3$. The FC1 and FC5 sites are north of Basin F while FC3 is south of Basin F. Aldrin, isodrin, PPDDE, and PPDDT were not measured in detectable quantities at any of the four sampling sites.

4.7.2.2 Quench Incinerator Construction Area High Event Period, June 20-21, 1991

OCPs were sampled during this high event period at three fixed sites (QI1, QI2 and FC2) and one mobile site (AQ25 or Mobile E) surrounding the quench incinerator construction site from 1100 MST, June 20 to 1100 MST, June 21, 1991. Figure 4.7-2 presents site locations, sampling results for the selected compounds, a wind rose depicting wind flow patterns during the sampling event and the result and dispersion pattern assuming the quench incinerator construction site was the primary emission source potentially contributing to ambient OCPs. The maximum ambient temperature for this event period was 87°F , with northwesterly to northeasterly prevailing wind flows during the sampling period. However, considerable wind flow variability was evident by the occurrence of hourly wind directions from ten of a possible sixteen wind direction radials.

Assuming that the quench incinerator construction area was the primary emission source of OCPs potentially contributing to ambient concentrations, the dispersion pattern indicates higher expected impacts in the immediate vicinity of the construction area and along a southeasterly and southwesterly axis from the construction area. The observed data supported this expectation for dieldrin. No other OCPs were detected for this sampling period. The highest level of dieldrin, $0.0027 \mu\text{g}/\text{m}^3$, occurred at FC2, southwest of the construction area. Similarly, the dieldrin level at the QI2 site ($0.0014 \mu\text{g}/\text{m}^3$)

southeast of the construction site, was higher than the concentrations measured at the QI1 and AQ25 (Mobile E) sites northwest and northeast of the construction area, respectively. The maximum dieldrin concentration was $0.0006 \mu\text{g}/\text{m}^3$ at the QI1 site and $0.0009 \mu\text{g}/\text{m}^3$ at the AQ25 site.

Although dieldrin was measured along the potential plume path depicted by the dispersion contours, it is difficult to determine if the quench incinerator was a source of this compound. Concentrations were very low, therefore these impacts could represent background conditions in the RMA area or transported in from outside the facility.

4.7.2.3 South Plants Subdrain Construction High Event Period, June 26-27, 1991

OCPs were sampled during this high event period at four mobile sites (AQ10, Mobile E, Mobile S and Mobile W) surrounding the South Plants subdrain construction area from 0800 MST, June 26 to 0800 MST, June 27, 1991. The Mobile E, Mobile S and Mobile W sites are grouped in the data summary tables as AQ01. Figure 4.7-3 presents site locations, sampling results for the selected compounds, a wind rose depicting wind flow patterns during the sampling event and the result and dispersion pattern assuming the South Plants subdrain construction site was the primary emission source potentially contributing to ambient OCPs. The maximum ambient temperature for this event period was 83°F , with northwesterly to northeasterly prevailing wind flows during the sampling period. However, considerable wind flow variability was evident by the occurrence of hourly wind directions from nine of a possible sixteen wind direction radials.

Assuming that the South Plants subdrain construction area was the primary emission source of OCPs potentially contributing to ambient concentrations, the dispersion pattern indicates higher expected impacts in the immediate vicinity of the construction area and along a southeasterly and southwesterly axis from the construction area. The observed data, however, did not consistently support this expectation for any of the measured OCPs. Although no consistent pattern was observed, it is possible to correlate the aldrin and dieldrin impacts to the construction activities.

Maximum aldrin impacts varied from a high concentration at Mobile W of $0.0338 \mu\text{g}/\text{m}^3$ (west of the construction area) to a low concentration at Mobile E of $0.0015 \mu\text{g}/\text{m}^3$ (east

of the construction area). The concentration at Mobile W represented the highest aldrin impact recorded during FY91. The aldrin impact at AQ10 (north of the construction area) and Mobile S (south of the construction area) were nearly identical at $0.0047 \mu\text{g}/\text{m}^3$ and $0.0050 \mu\text{g}/\text{m}^3$, respectively. Dieldrin, endrin and isodrin levels followed a similar pattern to that of aldrin. The highest level of dieldrin, $0.0618 \mu\text{g}/\text{m}^3$, occurred at Mobile W, west of the construction area. This concentration was also the highest dieldrin impact observed in FY91. The highest endrin, $0.0009 \mu\text{g}/\text{m}^3$, and isodrin $0.0009 \mu\text{g}/\text{m}^3$, concentrations also occurred at Mobile W, however, these concentrations were very low and varied only slightly from the other sampling location results.

Chlordane impacts were similar at all four sampling locations. Slightly higher chlordane concentrations of $0.0058 \mu\text{g}/\text{m}^3$ and $0.0056 \mu\text{g}/\text{m}^3$ were measured at Mobile W and AQ10, respectively, compared to $0.0049 \mu\text{g}/\text{m}^3$ and $0.0045 \mu\text{g}/\text{m}^3$ concentrations measured at Mobile S and Mobile E, respectively. No correlation with wind patterns were present for chlordane impacts. Therefore, the South Plants construction area is not a likely chlordane source.

One possible reason for the occurrence of elevated aldrin and dieldrin concentrations at the Mobile W site is the South Plant subdrain construction activities. It is probable that some quantity of aldrin and dieldrin was released during construction activities. Due to the close proximity of the sampling sites, only one site (in this case Mobile W) would have been impacted. This impact was probably very concentrated, short in duration, and occurred when the wind pattern was easterly or northeasterly. This hypothesis is further supported by the fact that the maximum 24-hour aldrin concentration level is similar to aldrin impact levels during similar activities performed during the Phase 2 and Phase 4 monitoring periods.

4.7.3 Basin F OCP Impacts

As previously discussed, a comprehensive evaluation of the ambient impacts from the Basin F cleanup operations and other remedial activities is performed by considering all CMP (AQ), Basin F Remedial Monitoring Program (BF), and IRA-F (FC) program data collected during the remedial and post-remedial periods. Some comparisons of data

from different monitoring periods have been presented in previous sections; however, this section will provide a more comprehensive comparative analysis.

4.7.3.1 CMP Data

Table 4.7-6 incorporates CMP FY88, FY89, FY90, and FY91 perimeter site data and stratifies the results for Phases 1 through 5. The CMP OCP data shows only small variations in concentrations across the RMA during remedial (Phases 1 and 2) and post-remedial (Phases 3, 4, and 5). These results show comparable concentration levels throughout the 43 month monitoring period. Table 4.7-7 shows a comparison of Phase 1 monitoring associated with remedial activities at the Basin F site and Phase 5 high event sampling results. Several target compounds identified in the FY88 report as potential Basin F contaminants continue to show a noticeable reduction in FY91. In particular, dieldrin, endrin, and isodrin levels are 10 to 100 times less in the post-remedial period.

The emphasis of the CMP has been to identify baseline air quality conditions at RMA remediation locations, perimeter sites, and other interior locations. The CMP program was designed to supplement and confirm the more intensive Basin F programs. The CMP program's primary function is to identify downwind concentrations of contaminants originating from Basin F activities and existing background conditions. As the data indicates, contaminant migration in the remedial and post-remedial phases has been minimal.

4.7.3.2 Basin F Data

Table 4.7-8 summarizes average and maximum 24-hour OCP concentrations for the Basin F Remedial Monitoring Program (BF) and the Basin F/IRA-F Monitoring Program (FC) for each phase of the remedial and post-remedial activities. All Phase 1 and 2 data were obtained from the Basin F Remedial Monitoring Program and cover the period from March 22, 1988 to May 5, 1989. The Phase 3 and 4 data were obtained from the IRA-F Monitoring Program and cover the post-remedial period from May 6, 1989 to September 30, 1990. The Phase 5 Stage 1 data were obtained from the IRA-F Monitoring Program from October 2, 1990 to January 18, 1991. The Phase 5 Stage 2 data were obtained from the integrated CMP and IRA-F Monitoring Program from

January 24 to September 30, 1991. Concentrations greater than the CRL were included in the annual and maximum summaries only when estimates of the actual values were available from the lab. Sequential data are provided in Appendix F.

Table 4.7-8 provides a detailed summary of each OCP contaminant during each phase of remediation. Initially, seven Basin F monitoring sites were used to monitor OCP impacts. The IRA-F Monitoring program incorporated the BF1, BF2, BF3, BF4 and BF5 sites and eliminated the BF6 and BF7 sites. Incorporation of the CMP and IRA-F program allowed for the addition of two new sites QI1 and QI2, located northwest of and in the predominant downwind direction of the Basin F area.

The Basin F data continues to show a generally marked reduction in FY91 OCP concentrations when compared to FY88 levels. In particular, aldrin, dieldrin, endrin, and isodrin levels during Phase 5 are as much as three orders of magnitude smaller on an average basis than Phase 1 sampling results. Chlordane, dichlorodiphenylethane (PPDDE) and dichlorodiphenyltrichloroethane (PPDDT) levels have remained fairly constant over time; however, chlordane shows a slight rise in the later phases. Comparisons in the post-remedial period show fairly constant levels.

Figures 4.7-4 through 4.7-8 show bar graph depictions of average concentrations of aldrin, chlordane, dieldrin, endrin and isodrin measured at selected sites during and after each phase of the remediation program. A significant reduction in the measured concentration of these contaminants was observed at the termination of the remediation program. In addition, a comparison of data between Basin F and perimeter sites (particularly in Phase 1) shows a decrease with distance for most contaminants. This suggests that Basin F was a principal emitter of many of these contaminants, and that impacts were localized and decreased rapidly beyond the immediate vicinity during remedial activity. CMP monitoring further confirmed these results.

As in the case of metals and VOC's, another approach to assessing remedial progress for OCPs is to consider Basin F impacts that were observed on individual days during the remedial and post-remedial periods. All Basin F air monitoring during the Phase 1 period was conducted for worst-case 24-hour periods based on dispersion model analysis and remedial activity. An example of the dispersion of OCPs resulting from Basin F

remedial activities is shown in Figure 4.7-9. This figure shows Phase 1 OCP concentrations for August 23, 1988, with X/Q dispersion values overlaying the monitoring data for seven Basin F stations. Again, this type of analysis identifies the potential dispersion of contaminants that would result from remedial actions being the primary source of ambient impacts.

During this sampling period, winds followed basically a typical diurnal cycle, with south to north flow during the night and north to south during the day. Wind speeds were mostly light and the maximum temperature was 88°F. On this day there were no detectable amounts of any pesticides at the upwind off-site Station BF7. Concentrations of aldrin, dieldrin, endrin and isodrin ranged from nondetectable to 0.7858 µg/m³ at the Basin F perimeter sites, but dropped considerably in value to less than 0.0478 µg/m³ at the further downwind sites BF5 and BF6. The actual concentrations followed quite closely the predicted dispersion pattern. The results indicate Basin F was clearly a source of these pesticides during the remediation phase.

A Phase 4 sample period with similar dispersion characteristics to the Phase 1 example was September 7-8, 1990, as shown in Figure 4.7-10. The winds during this period reflected a typical diurnal pattern, with light to moderate south-southwesterly flow at night and light north-northwesterly flow during the day. Maximum temperatures reached the low 80s. Contaminant levels for aldrin, dieldrin and endrin were significantly lower on this day than on the comparable Phase 1 day. Apparently, the Basin F area was still a minor source of several pesticides on this Phase 4, post-remediation day, although the concentrations were much smaller than during the remediation period.

4.7.3.3 Combined CMP and Basin F Data Analyses

Individual CMP and Basin F OCP monitoring data for the phases of the remedial and post-remedial monitoring programs were shown in Tables 4.7-7 and 4.7-8. Figures 4.7-11 through 4.7-12 provide illustrations of all available average and 24-hour maximum OCP data across the RMA complex for the Phase 1 remedial period and the Phase 5 post-remedial period. CMP data collected in the vicinity of Basin F are shown next to the Basin F data on these figures and printed in red. Samples were collected at the Basin F sites under both the IRA-F and the integrated CMP and IRA-F programs in FY91;

combined results of both programs are shown in Figure 4.7-12. The wind roses reflecting likely dispersion patterns are also shown in these figures. As noted from the previous discussions, the data show impacts for certain OCP compounds including aldrin, dieldrin, endrin and isodrin adjacent and immediately downstream from Basin F during the Phase 1 period. Further downstream, impacts were minimal and representative of the regional levels affecting the RMA. It appears from the data that Basin F OCP impacts were localized close to the remediation activities. During the post-remedial Phase 5 period, the impacts for most of the OCP component remained at similar levels as in Phase 4, the concentrations at all CMP and IRA-F monitoring sites appeared to be at normal baseline levels.

In summary, the data indicate that Basin F was a principal emitter of several OCPs during remediation activities. These impacts were localized and decreased significantly beyond the immediate vicinity of Basin F. Downwind monitoring stations, as reflected by the CMP perimeter locations (AQ1 through AQ5), indicated low to minimal OCP levels. During the Phase 3 through Phase 5 post-remedial periods, OCP levels appeared to decrease significantly, although very low levels of aldrin, dieldrin and isodrin continue to be measured near the Basin F area.

4.7.4 Summary of Results and Assessment of OCP Toxicity Levels

Table 4.7-9 summarizes maximum average and maximum 24-hour concentrations for the CMP, Basin F and IRA-F programs throughout the 43-month CMP monitoring period. Almost all of the highest concentrations occurred in the initial phases of remediation. Also, highest concentrations occurred most often at station BF2, located directly downwind of the predominant flow direction from Basin F.

In order to assess the significance of the measured OCP concentrations with respect to health standards and guidelines, a literature search was conducted using references and comparative analyses identical to those identified in the metals and VOC assessments.

A tabulation of guideline concentrations for comparison with measured OCP concentrations is presented in Table 4.7-10. The Phase 1 and Phase 2 remediation periods are grouped together and the Phase 3 through Phase 5 post-remediation periods

are shown separately. The comparison is very conservative because all CMP and Basin F data for remediation phases and some CMP and Basin F data for post-remediation phases cite averages of selected worst-case conditions. Nevertheless, this comparison is useful for identifying potential concerns during remedial operations and areas where CMP monitoring emphasis or remedial mitigation measures may be most appropriately directed. A review of the CMP and Basin F potential toxic concerns follows.

The highest 24-hour aldrin concentration, $2.83 \mu\text{g}/\text{m}^3$, was measured at BF2 during Phase 1. This level was slightly greater than the recommended typical 24-hour guideline level of $2.5 \mu\text{g}/\text{m}^3$. This high level was very localized in the immediate vicinity of remedial work occurring on the northeast perimeter of the Basin F Exclusion Zone. The maximum 24-hour, or short-term, levels at the other Basin F perimeter sites during Phase 1 ranged from $0.35 \mu\text{g}/\text{m}^3$ to $0.84 \mu\text{g}/\text{m}^3$. At the downwind Basin F sites, BF5, BF6, and BF7, maximum 24-hour aldrin values were $0.17 \mu\text{g}/\text{m}^3$, $0.04 \mu\text{g}/\text{m}^3$, and $0.01 \mu\text{g}/\text{m}^3$, respectively, or less than 6 percent of the short-term guideline. During Phase 1, the CMP OCP sampling did not directly measure aldrin, but aldrin was measured under the organics in total suspended particulates program using the pesticide analytical method. Measured 24-hour maximum aldrin values during Phase 1 ranged from $0.01 \mu\text{g}/\text{m}^3$ to $0.03 \mu\text{g}/\text{m}^3$, or about 0.4 to one percent of the short-term guideline levels, at the RMA perimeter sites.

The maximum long-term average aldrin concentration of $0.526 \mu\text{g}/\text{m}^3$ was measured at BF2 and was greater than the typical annual guideline level of $0.125 \mu\text{g}/\text{m}^3$. This average level was observed during Phase 1, and represents a seven-month sampling period. If the more restrictive RBAC at a 10^{-4} risk level of $0.02 \mu\text{g}/\text{m}^3$ is used, this maximum aldrin value at BF2 would be significantly above the risk-based concentration. However, these data represent an average of selected worst-case monitoring periods during peak remedial activity, and do not truly reflect the annual ambient concentrations for which the guideline was established. During the remedial phases, personnel working routinely in the vicinity of this location wore protective clothing and respirators. There were no other locations that exceeded either the annual NATICH or RBAC guideline values. Average concentrations fell off quickly from the BF2 monitoring location and

decreased significantly by Phase 3. Long-term average concentrations at the CMP perimeter stations were less than one percent of the typical guideline values.

Several other OCPs followed the same pattern as aldrin near the Basin F site, although aldrin indicated the highest percentages with respect to the toxic guidelines. The highest 24-hour endrin measurement was $1.10 \mu\text{g}/\text{m}^3$ at BF2 during Phase 1, or 98 percent of the 24-hour guideline of $1.12 \mu\text{g}/\text{m}^3$. Other Basin F perimeter station 24-hour maximum endrin levels ranged from $0.26 \mu\text{g}/\text{m}^3$ to $0.55 \mu\text{g}/\text{m}^3$ during Phase 1, decreasing to less than $0.01 \mu\text{g}/\text{m}^3$ during Phases 2 through 5. Maximum 24-hour endrin levels at the RMA perimeter stations measured below $0.01 \mu\text{g}/\text{m}^3$, or less than one percent of the average short-term NATICH guideline value.

The maximum long-term average endrin concentration was $0.134 \mu\text{g}/\text{m}^3$ at BF2 during Phase 1, or 87 percent of the annual guideline level of $0.155 \mu\text{g}/\text{m}^3$. This value represents the mean of limited CMP samples specifically selected to capture high events. More extensive Basin F monitoring at the same location during Phase 1 shows a mean value of $0.12 \mu\text{g}/\text{m}^3$. Downwind Basin F stations, BF5, BF6, and BF7 were at or below $0.01 \mu\text{g}/\text{m}^3$, which is seven percent of the annual average guideline level.

The maximum 24-hour dieldrin concentration of $2.30 \mu\text{g}/\text{m}^3$ was measured under the Basin F program at BF2 during Phase 1; this represents 70 percent of the 24-hour guideline level of $4.0 \mu\text{g}/\text{m}^3$. The 24-hour maximum values at other Basin F perimeter station during Phase 1 ranged from $1.66 \mu\text{g}/\text{m}^3$ at BF3 to $0.33 \mu\text{g}/\text{m}^3$ at BF4. Dieldrin at downwind Basin F stations ranged from $0.03 \mu\text{g}/\text{m}^3$ to $0.05 \mu\text{g}/\text{m}^3$, or about 1.0 to 1.5 percent of the 24-hour guideline level. Dieldrin levels decreased significantly during Phases 2 through 5. Concentrations at the RMA perimeter stations were measured at or below $0.02 \mu\text{g}/\text{m}^3$, or less than one percent of the respective average short-term guideline value.

The highest long-term average dieldrin concentration was $0.397 \mu\text{g}/\text{m}^3$, at BF2 during Phase 1. This concentration was greater than the annual guideline level of $0.125 \mu\text{g}/\text{m}^3$, but again represented the mean of only periods selected to measure high event emissions. More extensive Basin F monitoring during Phase 1 resulted in a maximum long-term average of $0.277 \mu\text{g}/\text{m}^3$. Dieldrin at downwind Basin F stations ranged from

0.004 $\mu\text{g}/\text{m}^3$ to 0.019 $\mu\text{g}/\text{m}^3$, or about fifteen percent of the annual average guideline level. Dieldrin levels decreased significantly during Phases 2 through 5, measuring at or below 0.029 $\mu\text{g}/\text{m}^3$, or less than twenty-five percent of the average long-term guideline. RMA perimeter sites measured dieldrin concentrations at or below 0.006 $\mu\text{g}/\text{m}^3$ during all phases, or about five percent of the average long-term guideline value. Concentrations near Basin F during Phases 2 through 5 were measured near the RBAC corresponding to a 10^4 risk level of 0.02 $\mu\text{g}/\text{m}^3$ while perimeter concentrations were less than 30 percent of this value.

Significant levels of isodrin were detected only during Phase 1 at the CMP Basin F (CMP/BF) sites. The maximum average isodrin concentration was 0.112 $\mu\text{g}/\text{m}^3$ and occurred at the BF2 site. The maximum 24-hour concentration of 0.945 $\mu\text{g}/\text{m}^3$ was also measured at BF2 during Phase 1. Very low levels of isodrin have been measured during the post-remedial phases, but these concentrations are at or below 0.001 and have been measured at RMA perimeter as well as Basin F sites. There are no health guideline levels listed for isodrin in Table 4.7-10.

Aldrin, endrin, and dieldrin were the three principal pesticides measured during the Basin F and CMP monitoring programs. Chlordane, isodrin, PPDDE, and PPDDT were measured at considerably lesser values and were all less than three percent of their respective short-term and long-term average NATICH guideline values. Long-term averaged concentrations of chlordane, PPDDE and PPDDT were measured at levels significantly below the RBAC at a 10^4 risk and frequently below the RBAC at a 10^{-6} risk. Parathion, malathion, atrazine, and Supona were also evaluated but only parathion was ever detected. Parathion was detected one time during Phase 1 at the BF2 station. The concentration was 0.21 $\mu\text{g}/\text{m}^3$, or about 20 percent of the average short-term NATICH guideline value.

In summary, Basin F appeared to be a potential source of several OCP compounds measured under the CMP and Basin F monitoring programs. In particular, aldrin, endrin, and dieldrin are traceable to Basin F remedial activities. Monitoring at station BF2, on the northeast perimeter of the basin resulted in the highest concentrations for most OCP compounds. Some of these concentrations were close to the health guideline levels for selected worst case monitoring scenarios. All downwind Basin F and RMA

perimeter stations reported monitoring results well below guideline levels and showed how concentrations decreased rapidly with distance from Basin F. Phase 2 through Phase 5 levels decreased dramatically for all monitoring locations from Phase 1 levels.

The decrease in OCP concentrations from Basin F potential sources over distance are illustrated in dispersion model results for various individual high event periods shown previously in this report. These data confirm the monitoring results and can be used to estimate downwind impacts beyond the limits of the monitoring network.

4.7.5 Seasonal Considerations

Table 4.7-11 shows the seasonal distribution of average and maximum 24-hour concentrations of OCPs measured at the CMP perimeter sites during the combined FY88, FY89, FY90, and FY91 monitoring periods. Average aldrin, endrin, and isodrin concentrations were highest during the fall season, especially at AQ3 on the northern perimeter of the RMA. The highest average concentrations of chlordane and dieldrin were measured in the summer, again at AQ3. PPDDE was detected only during the summer, with the highest level at AQ1. The highest average level of PPDDT was also measured in the summer at AQ1. In general, summer and fall concentrations were higher than those measured during the other seasons.

It appears from these results that metropolitan Denver was not a significant source of OCPs during the typical inversion and brown cloud periods that affected concentrations of TSP, metals, and VOCs. Rather, a regional source of OCPs may be north of the RMA, because of the relatively high readings at AQ3 during FY90 and FY91. It is also possible that the Basin F area may have made some contribution to the impacts at AQ3 during these periods.

TABLE 4.7-1
SUMMARY OF ROUTINE ORGANOCHLORINE PESTICIDE (OCP)
SAMPLING FOR FY91

Station	Samples Scheduled	Number of Samples	Percent Recovery
AQ1	21	20	95
AQ2	42	39	93
AQ3	42	39	93
AQ5	42	40	95
FC1	61	54	89
FC1C ¹	42	38	90
FC2	61	48	79
FC3	36	32	89
FC4	36	33	92
FC5	61	54	89
QI1	31	27	87
QI2	31	25	81
PROGRAM TOTAL	506	449	89

¹ FC1C is a collocated sampler. The intent and operation of collocated samplers are discussed in Section 8.4-Quality Assurance. Operation of FC1C began in Stage 2.

TABLE 4.7-2
SYNOPSIS OF FY91 HIGH EVENT MONITORING
FOR ORGANOCHLORINE PESTICIDES (OCPs)

Date	Period (24 Hours)	Site Locations
June 12-13, 1991	1200-1200	FC1,FC1C,FC2,FC3,FC5
June 20-21, 1991	1100-1100	FC2,QI1,QI1C,QI2, AQ25(Mobile E)
June 26-27, 1991	0800-0800	AQ10, AQ01(Mobile E,S,&W)

TABLE 4.7-3

**SUMMARY OF CMP ORGANOCHLORINE PESTICIDE (OCP)
CONCENTRATIONS FOR FY91 AT PERIMETER SITES (in $\mu\text{g}/\text{m}^3$)**

Site	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE 1	PPDDT 2
AVERAGE VALUES							
AQ1	*	0.000474	0.000187	*	*	*	*
AQ2	*	0.000451	0.000342	*	*	*	*
AQ3	0.000181	0.000534	0.000733	0.000182	*	*	*
AQ5	*	0.000267	0.000238	*	*	*	*
MAXIMUM 24-HOUR VALUES							
AQ1	*	0.002120	0.000421	*	*	*	*
AQ2	*	0.003220	0.001410	*	*	*	*
AQ3	0.000442	0.005930	0.004380	0.000494	*	*	*
AQ5	*	0.000923	0.000924	*	*	*	*

* All values below CRL

TABLE 4.7.4

**SUMMARY OF CMP ORGANOCHLORINE PESTICIDE (OCP)
CONCENTRATIONS FOR FY91 AT BASIN-F SITES (in $\mu\text{g}/\text{m}^3$)**

Site	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE 1	PPDDT 2
PHASE 5 - STAGE 1 AVERAGE VALUES							
FC1	*	0.000227	0.000807	0.000307	0.000213	*	0.000227
FC2	0.000244	0.000269	0.001575	0.000369	*	0.000213	0.000263
FC3	*	0.000240	0.000727	0.000273	*	*	0.000233
FC4	*	0.000256	0.000688	0.000269	*	*	*
FC5	*	0.000247	0.000760	0.000260	*	*	0.000227
PHASE 5 - STAGE 2 AVERAGE VALUES							
FC1	0.000274	0.001344	0.003069	0.000394	*	*	*
FC1C	0.000280	0.001448	0.003192	0.000390	*	*	*
FC2	0.000604	0.001963	0.009642	0.001037	0.000183	*	*
FC3	*	0.001089	0.002114	0.000276	*	*	*
FC4	*	0.000654	0.001589	0.000252	*	*	*
FC5	0.000259	0.001366	0.003054	0.000371	*	*	*
QI1	0.000269	0.001944	0.003521	0.000362	*	*	*
QI2	0.000208	0.002456	0.003821	0.000372	*	*	*

* All values below CRL

TABLE 4.7-4
(Concluded)

Site	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE 1	PPDDT 2
PHASE 5 - STAGE 1 24-HOUR MAXIMUM VALUES							
FC1	*	0.000400	0.001600	0.000700	0.000400	*	0.000400
FC2	0.000600	0.001100	0.005300	0.000700	*	0.000400	0.000500
FC3	*	0.000400	0.001900	0.000400	*	*	0.000500
FC4	*	0.000700	0.001800	0.000500	*	*	*
FC5	*	0.000500	0.001700	0.000500	*	*	0.000400
PHASE 5 - STAGE 2 24-HOUR MAXIMUM VALUES							
FC1	0.002530	0.008630	0.020000	0.002000	*	*	*
FC1C	0.002330	0.008800	0.021000	0.001870	*	*	*
FC2	0.006340	0.013000	0.061000	0.005480	0.000463	*	*
FC3	*	0.006700	0.017000	0.001120	*	*	*
FC4	*	0.005150	0.009200	0.000957	*	*	*
FC5	0.002070	0.007610	0.021000	0.001950	*	*	*
Q11	0.001420	0.009210	0.020000	0.001320	*	*	*
Q12	0.001050	0.015000	0.018000	0.001110	*	*	*

* All values below CRL22

TABLE 4.7-5

**SUMMARY OF CMP ORGANOCHLORINE PESTICIDE (OCP)
CONCENTRATIONS FOR FY91 DURING HIGH EVENT PERIODS (in $\mu\text{g}/\text{m}^3$)**

Site	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE 1	PPDDT 2
AVERAGE VALUES							
AQ01	0.013433	0.005067	0.028967	0.000767	0.000483	*	*
AQ10	0.004700	0.005600	0.022400	0.000900	0.000500	*	*
AQ25	*	*	0.000900	*	*	*	*
FC1	*	0.002800	0.003920	0.000459	*	*	*
FC1C	*	0.002500	0.003190	0.000391	*	*	*
FC2	*	0.001547	0.005675	0.000612	*	*	*
FC3	*	0.004100	0.002800	*	*	*	*
FC5	*	0.002410	0.003430	*	*	*	*
QI1	*	*	0.000551	*	*	*	*
QI1C	*	*	0.000900	*	*	*	*
QI2	*	*	0.001400	*	*	*	*

* All values below CRL

TABLE 4.7-5
(Concluded)

Site	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE 1	PPDDT 2
MAXIMUM 24-HOUR VALUES							
AQ01	0.033800	0.005800	0.061800	0.000900	0.001100	*	*
AQ10	0.004700	0.005600	0.022400	0.000900	0.000500	*	*
AQ25	*	*	0.000900	*	*	*	*
FC1	*	0.002800	0.003920	0.000459	*	*	*
FC1C	*	0.002500	0.003190	0.000391	*	*	*
FC2	*	0.002920	0.008660	0.001050	*	*	*
FC3	*	0.004100	0.002800	*	*	*	*
FC5	*	0.002410	0.003430	*	*	*	*
QI1	*	*	0.000551	*	*	*	*
QI1C	*	*	0.000900	*	*	*	*
QI2	*	*	0.001400	*	*	*	*

* All values below CRL

TABLE 4.7-6

**SUMMARY OF CMP ORGANOCHLORINE PESTICIDE (OCP)
CONCENTRATIONS BY PHASE AT PERIMETER SITES (in $\mu\text{g}/\text{m}^3$)**

Site	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDD 1		PPDDT 2		
						AVERAGE VALUES				
PHASE 1										
AQ1	0.0010	0.0003	0.0010	0.0006	0.0003	0.0005	*	0.0007	0.0007	
AQ3	0.0053	0.0003	0.0022	0.0013	0.0005	*	*	0.0004	0.0004	
AQ5	0.0013	0.0003	0.0013	0.0009	0.0003	0.0004	*	0.0006	0.0006	
PHASE 2										
AQ1	*	0.0003	0.0004	0.0004	*	*	*	0.0003	0.0003	
AQ3	*	0.0003	0.0004	0.0003	*	*	*	0.0003	0.0003	
AQ5	*	0.0003	0.0003	0.0003	*	*	*	*	*	
PHASE 3										
AQ1	*	0.0003	0.0004	*	*	*	*	0.0003	0.0003	
AQ3	*	0.0004	0.0008	*	*	*	*	0.0004	0.0004	
AQ5	*	0.0003	0.0005	*	*	*	*	0.0004	0.0004	
PHASE 4										
AQ1	0.0002	0.0003	0.0002	*	0.0002	*	*	*	*	
AQ3	0.0003	0.0005	0.0008	*	0.0002	*	*	*	*	
AQ5	0.0002	0.0003	0.0003	*	0.0002	*	*	*	*	
PHASE 5										
AQ1	*	0.0005	0.0002	*	*	*	*	*	*	
AQ2	*	0.0005	0.0003	*	*	*	*	*	*	
AQ3	0.0002	0.0005	0.0007	0.0002	0.0002	*	*	*	*	
AQ5	*	0.0003	0.0002	*	*	*	*	*	*	

* All values below CRL

TABLE 4.7-6
(Concluded)

Site	Aldrin	Chlordane	Dieldrin	MAXIMUM 24-HOUR VALUES			PPDD 1	PPDDT 2
				Endrin	Isodrin	PPDD 1		
PHASE 1								
AQ1	0.0066	0.0005	0.0062	0.0026	0.0005	0.0058	0.0047	
AQ3	0.0290	0.0005	0.0061	0.0041	0.0024	*	0.0012	
AQ5	0.0095	0.0008	0.0074	0.0046	0.0008	0.0023	0.0050	
PHASE 2								
AQ1	*	0.0003	0.0014	0.0011	*	*	0.0004	
AQ3	*	0.0004	0.0009	0.0004	*	*	0.0006	
AQ5	*	0.0004	0.0006	*	*	*	*	
PHASE 3								
AQ1	*	0.0004	0.0008	*	*	*	0.0006	
AQ3	*	0.0004	0.0026	*	*	*	0.0006	
AQ5	*	0.0004	0.0011	*	*	*	0.0005	
PHASE 4								
AQ1	0.0004	0.0015	0.0014	*	*	*	*	
AQ3	0.0014	0.0029	0.0047	0.0004	*	*	*	
AQ5	0.0002	0.0012	0.0015	*	*	*	*	
PHASE 5								
AQ1	*	0.0021	0.0004	*	*	*	*	
AQ2	*	0.0032	0.0014	*	*	*	*	
AQ3	0.0004	0.0059	0.0044	0.0005	*	*	*	
AQ5	*	0.0009	0.0009	*	*	*	*	

* All values below CRL

TABLE 4.7-7

**SUMMARY OF CMP ORGANOCHLORINE PESTICIDE (OCP)
CONCENTRATIONS BY PHASE DURING HIGH EVENT PERIODS (in $\mu\text{g}/\text{m}^3$)**

Site	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE 1	PPDDT 2
PHASE 1							
AQ1	*	0.0011	0.0036	0.0013	0.0006	0.0006	0.0014
AQ2	*	*	*	*	*	*	*
AQ3	*	0.0010	0.0060	0.0014	*	*	0.0008
AQ4	*	*	*	*	*	*	*
AQ5	*	0.0011	0.0021	0.0014	*	*	0.0023
AQ6	*	*	*	0.0040	*	*	*
AQ8	*	*	*	*	0.0390	*	*
AQ9	*	*	*	*	0.0198	*	*
CMP/BF1	*	*	0.2245	0.1208	0.0363	*	0.0069
CMP/BF2	*	*	0.2971	0.1343	0.1122	*	0.0350
CMP/BF3	*	*	0.0423	0.0718	0.0054	*	*
CMP/BF4	*	0.0036	0.0584	0.0160	0.0040	*	0.0022
PHASE 5							
AQ01	0.0134	0.0051	0.0290	0.0008	0.0005	*	*
AQ10	0.0047	0.0056	0.0224	0.0009	0.0005	*	*
AQ25	*	*	0.0009	*	*	*	*
FC1	*	0.0028	0.0039	0.0005	*	*	*
FC1C	*	0.0025	0.0032	0.0004	*	*	*
FC2	*	0.0015	0.0057	0.0006	*	*	*
FC3	*	0.0041	0.0028	*	*	*	*
FCS	*	0.0024	0.0034	*	*	*	*
Q11	*	*	0.0006	*	*	*	*
Q11C	*	*	0.0009	*	*	*	*
Q12	*	*	0.0014	*	*	*	*

* All values below CRL

TABLE 4.7-7
(Concluded)

Site	Aldrin	Chlordane	Dieldrin	Endrin	MAXIMUM 24-HOUR VALUES		PPDDDE 1	PPDDT 2						
					Isodrin	Isodrin								
PHASE 1														
AQ1	*	0.0023	0.0060	0.0028	0.0008	*	0.0008	0.0034						
AQ2	*	*	*	*	*	*	*	*						
AQ3	*	0.0024	0.0217	0.0027	*	*	*	0.0010						
AQ4	*	*	*	*	*	*	*	*						
AQ5	*	0.0028	0.0044	0.0032	*	*	*	0.0067						
AQ6	*	*	*	0.0040	*	*	*	*						
AQ8	*	*	*	*	0.0390	*	*	*						
AQ9	*	*	*	*	0.0387	*	*	*						
CMP/BF1	*	*	0.2245	0.1208	0.0363	*	*	0.0069						
CMP/BF2	*	*	0.7210	0.2371	0.2525	*	*	0.0585						
CMP/BF3	*	*	0.0423	0.0718	0.0054	*	*	*						
CMP/BF4	*	0.0036	0.0584	0.0160	0.0040	*	*	0.0022						
PHASE 5														
AQ01	0.0338	0.0058	0.0618	0.0009	0.0011	*	*	*						
AQ10	0.0047	0.0056	0.0224	0.0009	0.0005	*	*	*						
AQ25	*	*	0.0009	*	*	*	*	*						
FC1	*	0.0028	0.0039	0.0005	*	*	*	*						
FC1C	*	0.0025	0.0032	0.0004	*	*	*	*						
FC2	*	0.0029	0.0087	0.0011	*	*	*	*						
FC3	*	0.0041	0.0028	*	*	*	*	*						
FC5	*	0.0024	0.0034	*	*	*	*	*						
QI1	*	*	0.0006	*	*	*	*	*						
QI1C	*	*	0.0009	*	*	*	*	*						
QI2	*	*	0.0014	*	*	*	*	*						

* All values below CRL

TABLE 4.7-8
SUMMARY OF BASIN F/IRA-F ORGANOCHLORINE PESTICIDE (OCP)
CONCENTRATIONS BY PHASE (in $\mu\text{g}/\text{m}^3$)

Site	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE 1	PPDDT 2
PHASE 1							
BF1	0.1913	*	0.1408	0.0719	0.0076	*	*
BF2	0.4579	*	0.2768	0.1209	0.0424	*	*
BF2C	0.5263	*	0.2475	0.1142	0.0584	*	*
BF3	0.0662	*	0.0898	0.0250	0.0017	*	*
BF4	0.0499	*	0.0477	0.0234	0.0030	*	*
BF5	0.0221	*	0.0193	0.0096	0.0011	*	*
BF6	0.0058	*	0.0083	0.0031	0.0004	*	*
BF7	0.0016	*	0.0038	0.0011	0.0003	*	0.0008
PHASE 2 - STAGE 1							
BF1	0.0106	*	0.0075	0.0041	0.0013	*	*
BF2	0.0154	*	0.0107	0.0044	0.0010	*	*
BF2C	0.0071	0.0071	0.0079	0.0047	0.0008	0.0013	0.0007
BF3	0.0026	*	0.0032	0.0017	0.0005	*	*
BF4	0.0034	*	0.0027	0.0014	0.0007	*	*
BF5	0.0010	*	0.0010	0.0008	*	*	*
BF6	0.0006	*	0.0012	0.0011	0.0003	*	*
BF7	*	*	0.0008	0.0007	*	*	*
PHASE 2 - STAGE 2							
BF1	0.0023	*	0.0057	0.0024	0.0003	*	*
BF2	0.0022	*	0.0076	0.0019	*	*	*
BF2C	0.0017	*	0.0077	0.0023	*	0.0007	*
BF3	0.0006	*	0.0031	0.0010	*	*	*
BF4	0.0007	*	0.0020	0.0010	*	*	*
BF5	0.0005	*	0.0011	0.0007	*	*	*
BF6	0.0004	*	0.0015	0.0008	*	*	0.0002
BF7	*	*	0.0009	*	*	*	*

* All values below CRL.

TABLE 4.7-8
(Continued)

Site	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE 1	PPDDT 2
AVERAGE VALUES							
PHASE 3							
FC1	0.0006	0.0004	0.0047	0.0006	0.0002	*	*
FC2	0.0014	0.0006	0.0121	0.0013	0.0004	0.0003	0.0002
FC2D	0.0016	0.0005	0.0130	0.0013	0.0014	*	0.0002
BF3/FC3	0.0004	0.0005	0.0074	0.0006	0.0003	*	0.0002
BF4/FC4	0.0005	0.0004	0.0061	0.0007	0.0002	*	*
BF5	0.0002	0.0002	0.0015	0.0003	*	*	*
FC5	0.0006	0.0003	0.0032	0.0003	*	*	*
BF7	0.0002	0.0004	0.0024	0.0004	*	*	*
PHASE 4							
FC1	0.0005	0.0003	0.0034	0.0004	0.0002	*	0.0002
FC2	0.0012	0.0004	0.0086	0.0009	0.0002	*	0.0004
FC2D	0.0018	0.0003	0.0098	0.0010	0.0002	*	0.0004
FC3	0.0004	0.0003	0.0034	0.0004	0.0002	0.0003	0.0002
FC4	0.0007	0.0003	0.0052	0.0005	0.0002	*	0.0002
FC5	0.0004	0.0003	0.0029	0.0005	0.0002	*	0.0002
PHASE 5 - STAGE 1							
FC1	*	0.0002	0.0008	0.0003	0.0002	*	0.0002
FC2	0.0002	0.0003	0.0016	0.0004	*	*	0.0003
FC3	*	0.0002	0.0007	0.0003	*	*	0.0002
FC4	*	0.0003	0.0007	0.0003	*	*	*
FC5	*	0.0002	0.0008	0.0003	*	*	0.0002
PHASE 5 - STAGE 2							
FC1	0.0003	0.0013	0.0031	0.0004	*	*	*
FC1C	0.0003	0.0014	0.0032	0.0004	*	*	*
FC2	0.0006	0.0020	0.0096	0.0010	0.0002	*	*
FC3	*	0.0011	0.0021	0.0003	*	*	*
FC4	*	0.0007	0.0016	0.0003	*	*	*
FC5	0.0003	0.0014	0.0031	0.0004	*	*	*

* All values below CRL

TABLE 4.7-8
(Continued)

Site	Aldrin	Chlordane	Dieldrin	Endrin	MAXIMUM 24-HOUR VALUES		PPDDT 1	PPDDT 2
					Isodrin			
PHASE 1								
BF1	0.8366	*		0.4904	0.2497		0.0604	*
BF2	2.8290	*		2.2960	0.9020		0.8160	*
BF2C	2.5773	*		2.1478	1.0954		0.9450	*
BF3	0.4288	*		1.6568	0.5458		0.0226	*
BF4	0.3478	*		0.3265	0.2591		0.1136	*
BF5	0.1723	*		0.0499	0.0275		0.0080	*
BF6	0.0369	*		0.0256	0.0093		0.0016	*
BF7	0.0124	*		0.0479	0.0050		0.0007	0.0017
PHASE 2 - STAGE 1								
BF1	0.0830	*		0.0361	0.0223		0.0114	*
BF2	0.1244	*		0.0355	0.0147		0.0100	*
BF2C	0.0210	0.0360	0.0310	0.0130	0.0020		0.0060	0.0010
BF3	0.0234	*		0.0130	0.0061		0.0034	*
BF4	0.0321	*		0.0099	0.0042		0.0078	*
BF5	0.0080	*		0.0030	0.0010		*	*
BF6	0.0020	*		0.0040	0.0040		0.0020	*
BF7	*	*		0.0010	0.0010		*	*
PHASE 2 - STAGE 2								
BF1	0.0190	*		0.0190	0.0070		0.0010	*
BF2	0.0230	*		0.0340	0.0100		*	*
BF2C	0.0090	*		0.0330	0.0100		0.0010	*
BF3	0.0050	*		0.0110	0.0030		*	*
BF4	0.0040	*		0.0070	0.0040		*	*
BF5	0.0020	*		0.0030	0.0010		*	*
BF6	0.0010	*		0.0050	0.0010		0.0007	*
BF7	*	*		0.0017	*		*	*

* All values below CRL

TABLE 4.7-8
(Concluded)

Site	Aldrin	Chlordane	Dieldrin	Ecdrin	Isodrin	PPDDE 1	PPDDT 2
MAXIMUM 24-HOUR VALUES							
PHASE 3							
FC1	0.0041	0.0010	0.0188	0.0015	0.0005	*	*
FC2	0.0103	0.0015	0.0444	0.0045	0.0011	*	0.0010
FC2D	0.0088	0.0011	0.0424	0.0034	0.0106	*	0.0006
BF3/FC3	0.0017	0.0019	0.0240	0.0021	0.0006	*	0.0004
BF4/FC4	0.0016	0.0014	0.0179	0.0022	0.0005	*	*
BF5	0.0004	0.0005	0.0023	0.0004	*	*	*
FC5	0.0033	0.0007	0.0159	0.0008	*	*	*
BF7	0.0004	0.0010	0.0053	0.0006	0.0005	*	*
PHASE 4							
FC1	0.0079	0.0015	0.0310	0.0022	0.0004	*	0.0006
FC2	0.0300	0.0023	0.0720	0.0063	0.0011	*	0.0041
FC2D	0.0270	0.0015	0.0640	0.0064	0.0005	*	0.0038
FC3	0.0035	0.0023	0.0270	0.0039	0.0007	0.0006	0.0014
FC4	0.0095	0.0014	0.0430	0.0034	0.0004	*	0.0020
FC5	0.0073	0.0018	0.0260	0.0067	0.0004	*	0.0009
PHASE 5 - STAGE 1							
FC1	*	0.0004	0.0016	0.0007	0.0004	*	0.0004
FC2	0.0006	0.0011	0.0053	0.0007	*	0.0004	0.0005
FC3	*	0.0004	0.0019	0.0004	*	*	0.0005
FC4	*	0.0007	0.0018	0.0005	*	*	*
FC5	*	0.0005	0.0017	0.0005	*	*	0.0004
PHASE 5 - STAGE 2							
FC1	0.0025	0.0086	0.0200	0.0020	*	*	*
FC1C	0.0023	0.0088	0.0210	0.0019	*	*	*
FC2	0.0063	0.0130	0.0610	0.0055	*	*	*
FC3	*	0.0067	0.0170	0.0011	*	*	*
FC4	*	0.0052	0.0092	0.0010	*	*	*
FC5	0.0021	0.0076	0.0210	0.0020	*	*	*

* All values below CRL

TABLE 4.7-9

**MAXIMUM AVERAGE LONG-TERM AND SHORT-TERM
ORGANOCHLORINE PESTICIDE (OCP) CONCENTRATIONS (in $\mu\text{g}/\text{m}^3$)**

OCP	Maximum Long-Term Average	Location	Phase	Maximum Short-Term Concentration	Location	Phase
Aldrin	0.5263	BF2	P1	2.8290	BF2	P1
Chlordane	0.0071	BF2	P2-S1	0.0360	BF2	P2-S1
Dieldrin	0.3971	CMP/BF2	P1	2.2960	BF2	P1
Endrin	0.1343	CMP/BF2	P1	1.0954	BF2	P1
Isodrin	0.1122	CMP/BF2	P1	0.9450	BF2	P1
PPDDE	0.0390	AQ8	P1	0.0390	AQ8	P1
PPDDT	0.0350	CMP/BF2	P1	0.0585	CMP/BF2	P1

* Several maximum long-term averages provided in this table represent limited sampling from the CMP high event periods. More extensive long-term monitoring results for the Basin F Monitoring program are shown in Table 4.7-8.

Legend:

PPDDE	=	Dichlorodiphenylethane
PPDDT	=	Dichlorodiphenyltrichloroethane
P1	=	Phase 1
P2-S1	=	Phase 2-Stage 1

TABLE 4.7-10

**ROCKY MOUNTAIN ARSENAL ORGANOCHLORINE PESTICIDE (OCP)
CONCENTRATION COMPARISONS TO HEALTH GUIDELINES**

OCP	CAS #	TLV (ppm)	10 ⁻⁴	10 ⁻⁶	RfC	Chronic RBAC* ($\mu\text{g}/\text{m}^3$)		RMA Total Sites Evaluation (Phase 1 and Phase 2 only)			RMA Perimeter Sites Evaluation (Phase 1 and Phase 2 only)			
						Lifetime Excess Cancer Risk Level	Typical Guideline Levels [†]	Maximum Concentrations	Percent of Guideline Levels ^{‡,§}	Long Term 24-hour ($\mu\text{g}/\text{m}^3$)	Long Term 24-hour ($\mu\text{g}/\text{m}^3$)	Long Term 24-hour ($\mu\text{g}/\text{m}^3$)	Maximum Perimeter Concentrations	Percent of Guideline Levels [†]
Aldrin	309-00-2	0.015	0.02	0.0002	0.6-6.0	0.0002- 0.25	2.8290	0.5263	86	>100	0.0290	0.0053	9	4
Chlordane	57-74-9	0.027	0.3	0.0027	0.14-12	0.0027- 0.5	0.0360	0.0071	1	3	0.0028	0.0011	<1	<1
Dieldrin	60-57-1	0.015	0.02	0.00022	0.6-6	0.00027- 0.25	2.2960	0.3971	70	>100	0.0217	0.0060	7	5
Endrin	72-20-8	0.006	NA	NA	0.24-2	0.01-0.3	1.0954	0.1343	98	87	0.0046	0.0014	4	1
Isoodrin	465-73-6		NA	NA			0.9450	0.1122			0.0024	0.0006		
PPDDE	72-55-9		NA	NA			1.8	0.0390	0.0390	2	0.0058	0.0006	<1	
PPDDT	50-29-3	0.063	1.0	0.01	1.0-24	0.01-10	0.0585	0.0350	<1	1	0.0067	0.0023	<1	<1
													(Phases 3 through 5 only)	
Aldrin	309-00-2	0.015	0.02	0.0002	0.6-6.0	0.0002- 0.25	0.0338	0.0134	10	11	0.0014	0.0003	<1	<1
Chlordane	57-74-9	0.027	0.3	0.0027	0.14-12	0.0027- 0.5	0.0130	0.0056	2	2	0.0059	0.0005	<1	<1
Dieldrin	60-57-1	0.015	0.02	0.00022	0.6-6	0.00027- 0.25	0.0720	0.0290	2	23	0.0047	0.0008	1	1
Endrin	72-20-8	0.006	NA	NA	0.24-2	0.01-0.3	0.0067	0.0013	1	1	0.0005	0.0002	<1	<1
Isoodrin	465-73-6		NA	NA			0.0106	0.0014			0.0009	0.0003		

TABLE 4.7-10
(Concluded)

OCP	CAS #	Chronic RBAC* ($\mu\text{g}/\text{m}^3$)			RMA Total Sites Evaluation (Phase 1 and Phase 2 only)			RMA Perimeter Sites Evaluation (Phase 1 and Phase 2 only)		
		TLV (ppm)	10 ⁻⁴	10 ⁻⁶	Typical Guideline Levels ⁺	Maximum Concentrations	Percent of Guideline Levels ⁺⁺	Maximum Perimeter Concentrations	Percent of Guideline Levels ⁺	
PPDDE	72-55-9	NA	NA	NA	Short Term ($\mu\text{g}/\text{m}^3$)	Long Term ($\mu\text{g}/\text{m}^3$)	Long Term ($\mu\text{g}/\text{m}^3$)	Long Term ($\mu\text{g}/\text{m}^3$)	Long Term ($\mu\text{g}/\text{m}^3$)	Long Term ($\mu\text{g}/\text{m}^3$)
PPDDT	50-29-3	0.063	1.0	0.01	1.0-24	0.01-10	0.0041	0.0004	3	<1

⁺ Range of values represent upper and lower bound state guideline levels as found in NATICH.

⁺⁺ Based on arithmetic average of upper and lower bound guideline values

Legend: TLV = Threshold Limit Value

RBAC* = Risk-based concentration for long-term (lifetime) residential exposures. RBAC's for carcinogens are derived from unit risks reported in EPA's Integrated Risk Information System (IRIS) database or EPA's Health Effects Assessment Summary Tables (HEAST 1992). RBAC's for non carcinogens are Reference Concentrations (RFC's) reported in same documents.

NA = Not Available

TABLE 4.7-11
COMBINED SEASONAL ORGANOCHLORINE PESTICIDE (OCP)
CONCENTRATIONS (in $\mu\text{g}/\text{m}^3$)

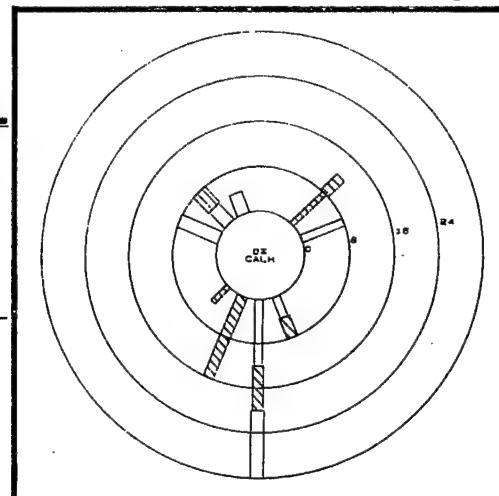
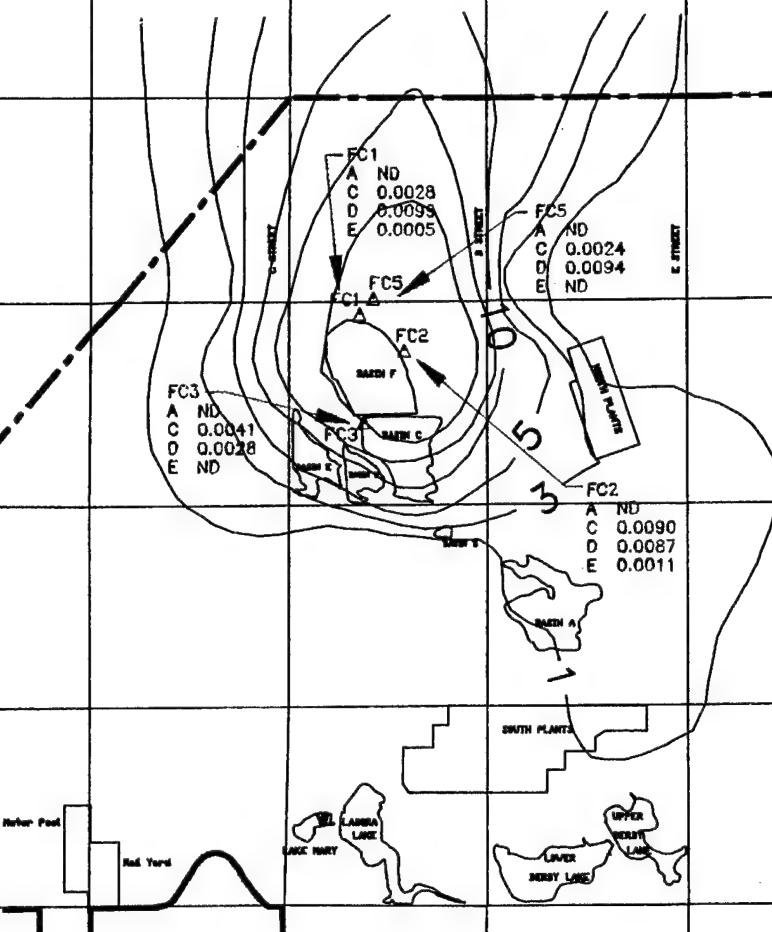
Season	Site	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE 1	PPDDT 2
AVERAGE VALUES								
Fall	AQ1	0.00102	0.00028	0.00052	0.00038	0.00085	*	0.00036
	AQ2	ND	ND	ND	ND	ND	ND	ND
	AQ3	0.00625	*	0.00137	0.00089	0.00061	*	*
	AQ5	0.00161	0.00032	0.00063	0.00042	0.00036	*	0.00039
Winter	AQ1	*	0.00023	0.00029	0.00027	*	*	0.00025
	AQ2	*	*	*	*	*	*	*
	AQ3	*	0.00023	0.00029	*	*	*	*
	AQ5	*	0.00025	0.00027	*	*	*	0.00027
Spring	AQ1	0.00026	0.00024	0.00034	*	*	*	*
	AQ2	*	*	0.00033	*	*	*	*
	AQ3	*	0.00030	0.00086	*	*	*	0.00028
	AQ5	*	0.00027	0.00036	*	*	*	*
Summer	AQ1	0.00035	0.00052	0.00062	0.00038	0.00022	0.00040	0.00045
	AQ2	*	0.00089	0.00048	*	*	*	*
	AQ3	0.00087	0.00063	0.00150	0.00064	0.00024	*	0.00031
	AQ5	0.00055	0.00037	0.00086	0.00054	0.00023	0.00028	0.00043

* All values below CRL
 ND No data available

**TABLE 4.7-11
(Concluded)**

Season	Site	Aldrin	Chlordane	Dieldrin	Ecdrin	Isodrin	PPDDE 1	PPDDT 2
24-HOUR MAXIMUM VALUES								
Fall	AQ1	0.00659	0.00037	0.00153	0.00087	0.00093	*	0.00083
	AQ2	ND	ND	ND	ND	ND	ND	ND
	AQ3	0.02898	*	0.00607	0.00259	0.00242	*	*
	AQ5	0.00945	0.00048	0.00278	0.00131	0.00078	*	0.00081
Winter	AQ1	*	0.00033	0.00143	0.00112	*	*	0.00038
	AQ2	*	*	*	*	*	*	*
	AQ3	*	0.00034	0.00094	*	*	*	*
	AQ5	*	0.00037	0.00058	*	*	*	0.00057
Spring	AQ1	0.00036	0.00041	0.00142	*	*	*	*
	AQ2	*	*	0.00091	*	*	*	*
	AQ3	*	0.000212	0.00360	*	*	*	0.00058
	AQ5	*	0.00036	0.00086	*	*	*	*
Summer	AQ1	0.00428	0.00212	0.00619	0.00264	0.00051	0.00576	0.00467
	AQ2	*	0.00322	0.00141	*	*	*	*
	AQ3	0.00673	0.00593	0.00559	0.00406	0.00072	*	0.00116
	AQ5	0.00394	0.00120	0.00738	0.00459	0.00041	0.00231	0.00503

* All values below CRL
ND No data available



QI2 △ Comprehensive Monitoring Location

FC2 △ CMP FC Sites (Formerly IRA-F)

A = Aldrin
 C = Chlordane
 D = Dieldrin
 E = Endrin
 ND = Non-Detectable

24 Hour Maximum (ug/m³)

Source: Basin F

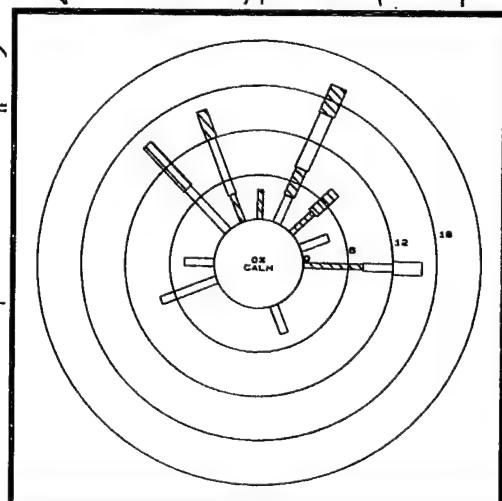
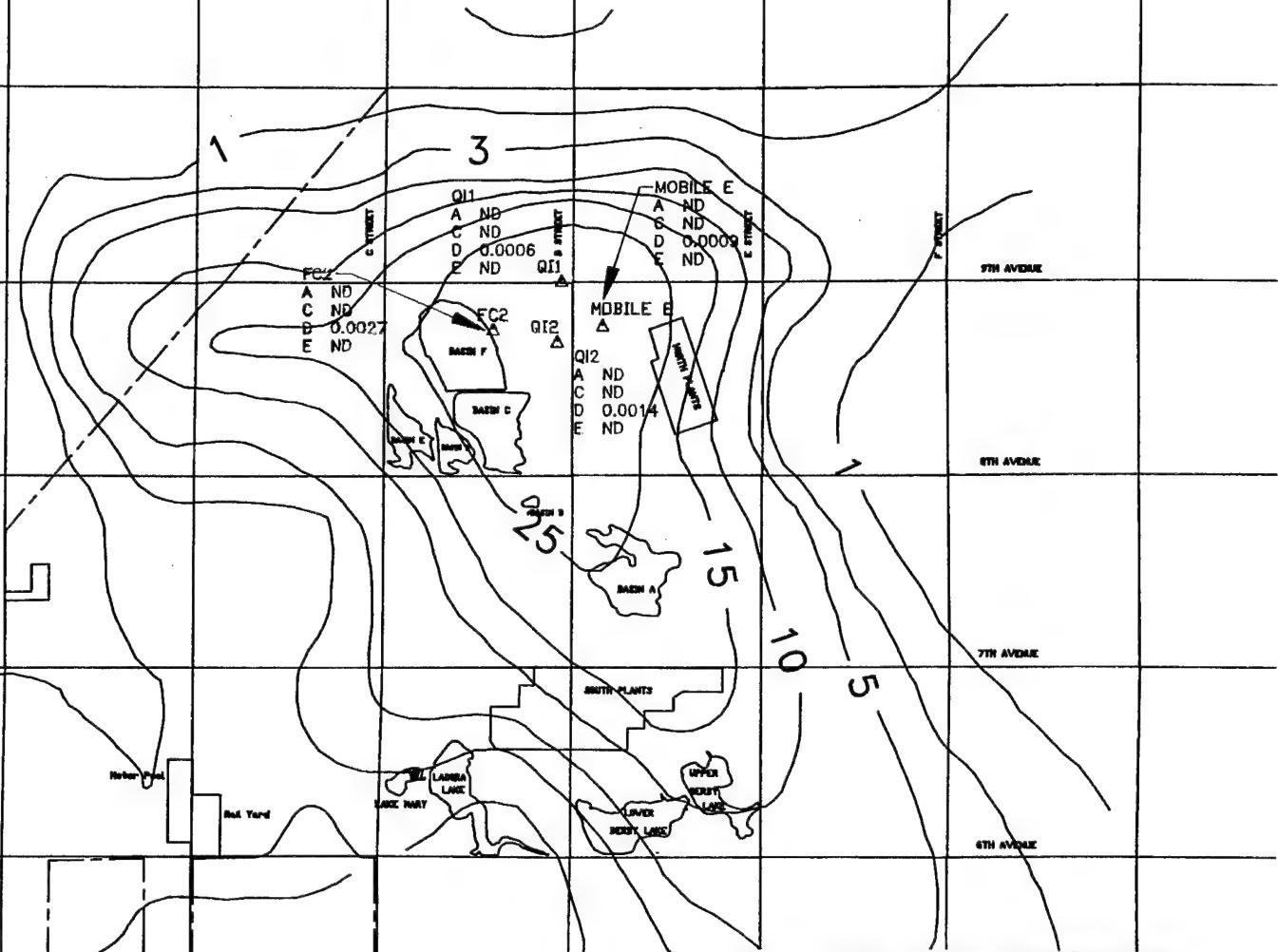
5000 0 5000 10000
SCALE Feet



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

OCP Results and x/Q Dispersion for 06/12/91
CMP Air Quality Data Rocky Mountain Arsenal
U.S. Program Manager
Rocky Mountain Arsenal

DRWN BY :	dwb	DATE :	5/5/92	PROJECT NO:	22787E
CHKD BY :	.	DATE :	.	FIG. NO :	4.7-1



QI2 Δ Comprehensive Monitoring Location

FC2 Δ CMP FC Sites (Formerly IRA-F)

A = Aldrin
C = Chlordane
D = Dieldrin
E = Endrin
ND = Non-Detectable

24 Hour Maximum ($\mu\text{g}/\text{m}^3$)

Source: Quench Incinerator

5000 0 5000 10000
SCALE Feet



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

OCP Results and x/Q Dispersion for 06/20/91
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

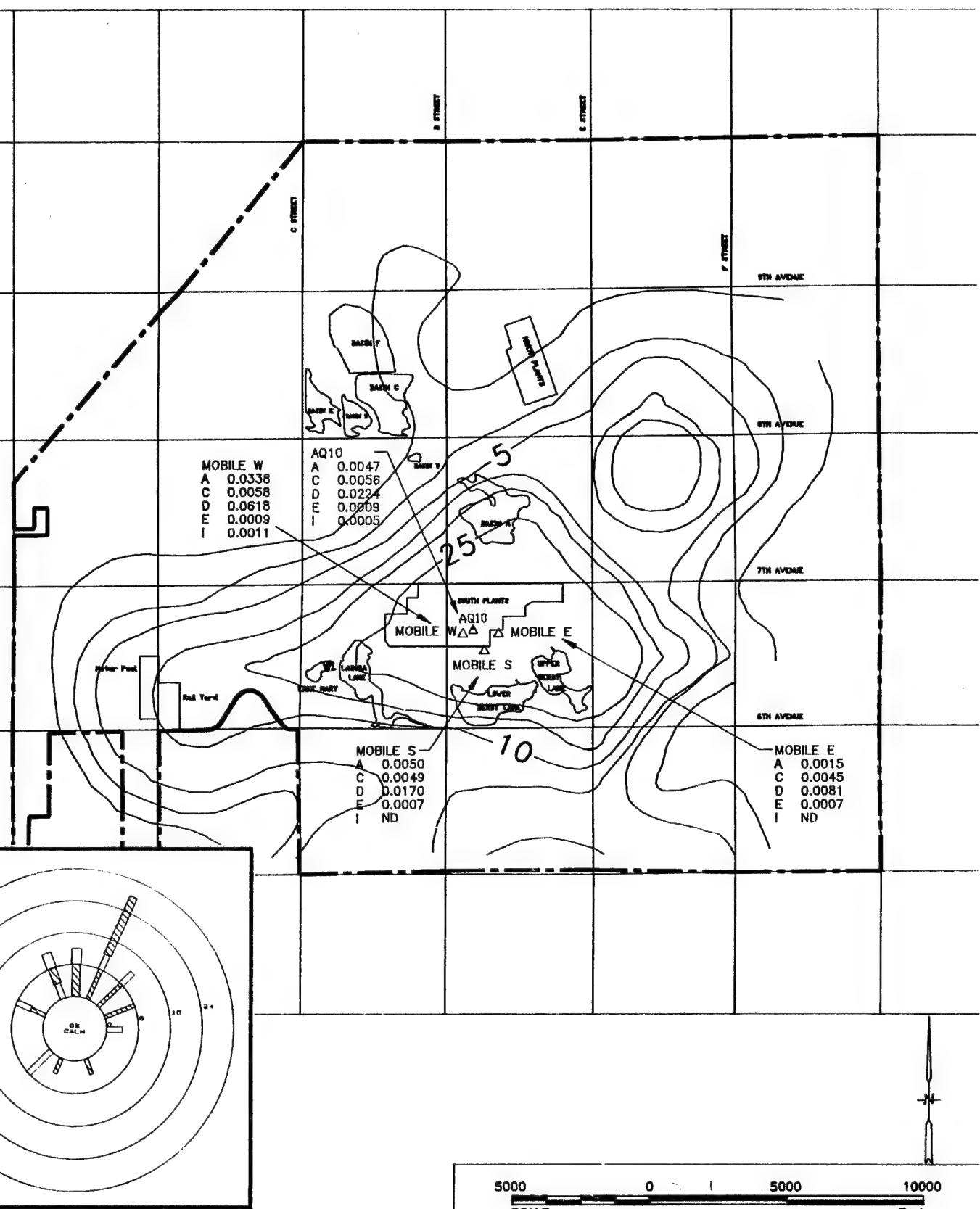
Rocky Mountain Arsenal

DRWN BY : dwb DATE : 5/5/92

PROJECT NO: 22787E

CHKD BY : DATE :

FIG. NO : 4.7-2



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

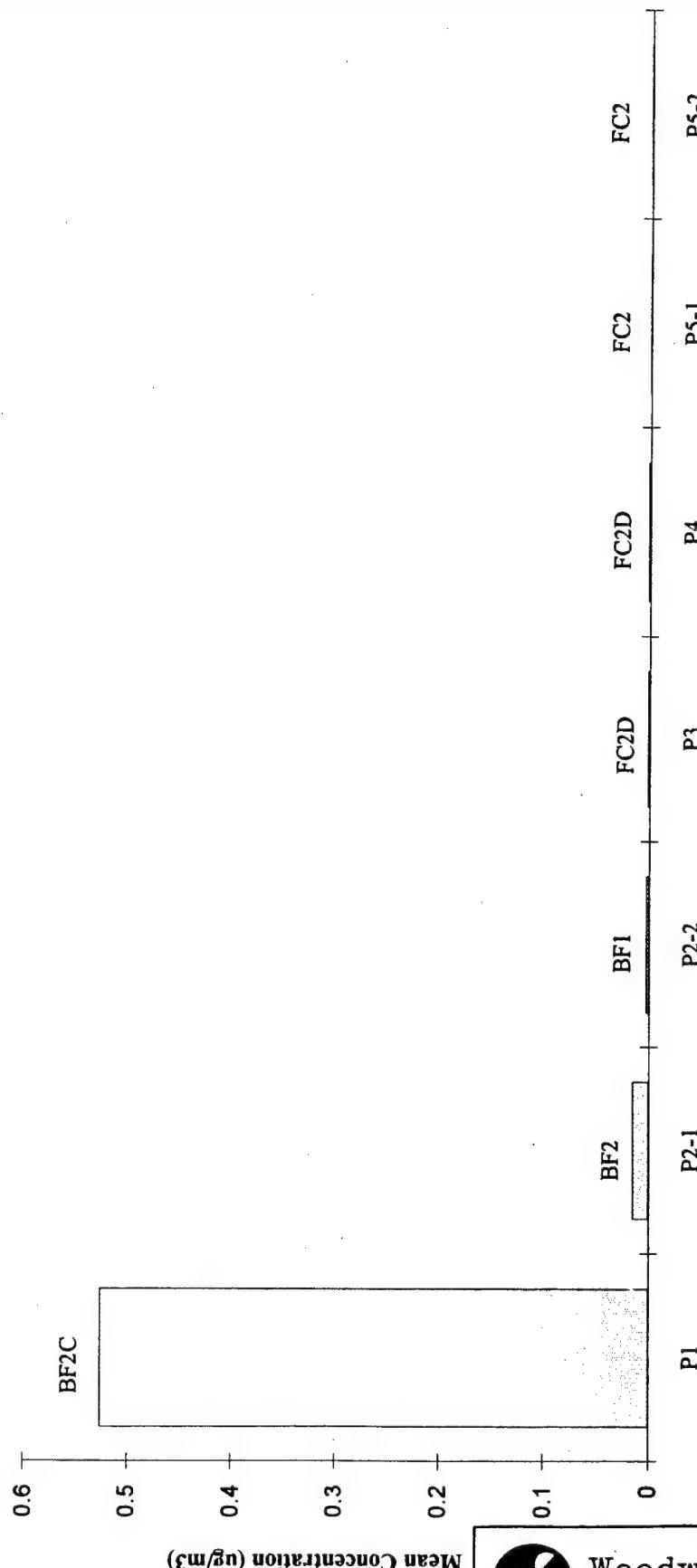
OCP Results and x/Q Dispersion for 06/26/91
CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	dwb	DATE :	5/5/92	PROJECT NO:	22787E
CHKD BY :	.	DATE :	.	FIG. NO :	4.7-3

Aldrin By Phase



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

ALDRIN BY PHASE

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :

DATE :

PROJECT NO:

FIG. NO :

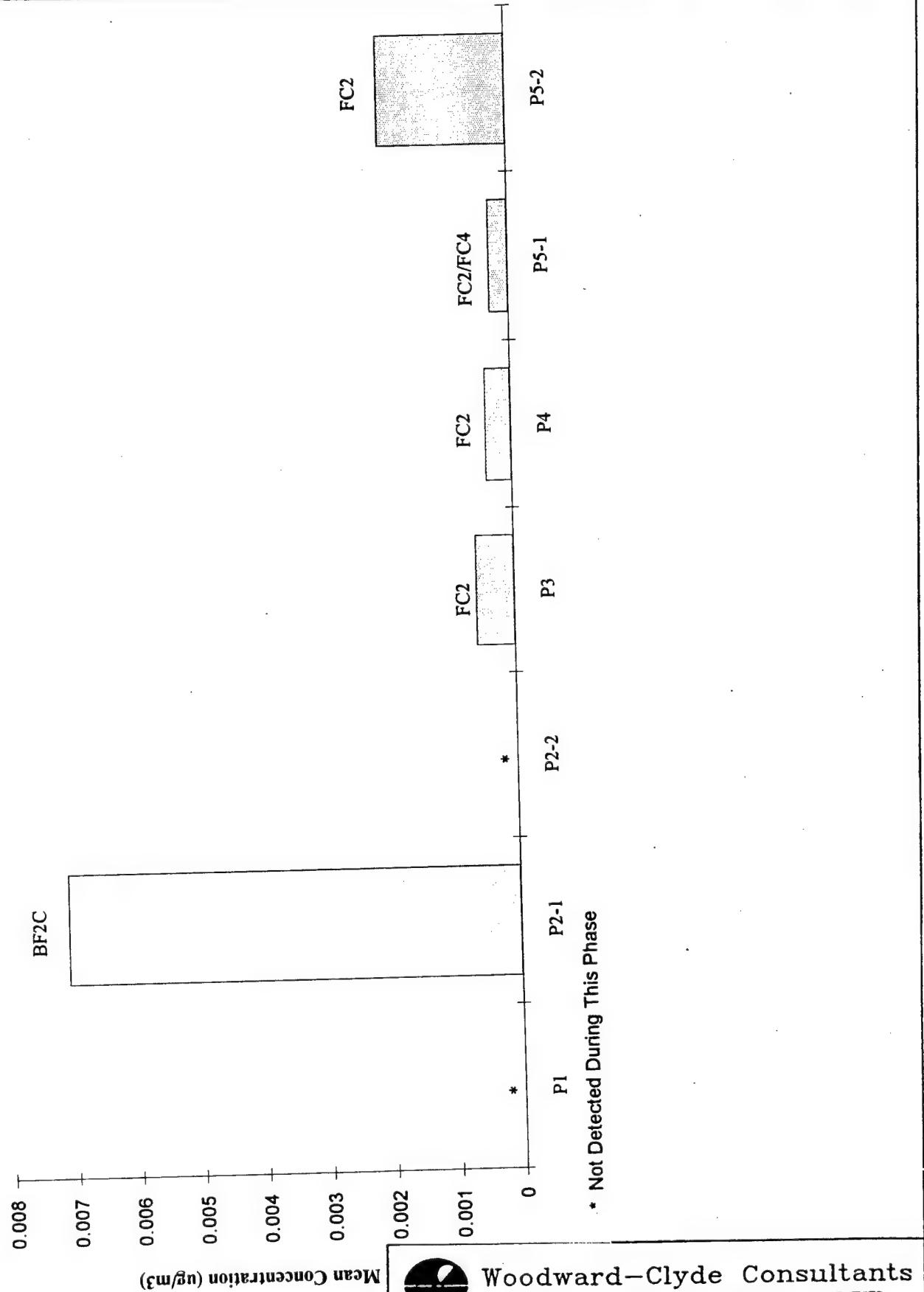
CHKD BY :

DATE :

22787E

4.7-4

Chlordane By Phase



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

CHLORDANE BY PHASE

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :

DATE :

PROJECT NO:

FIG. NO :

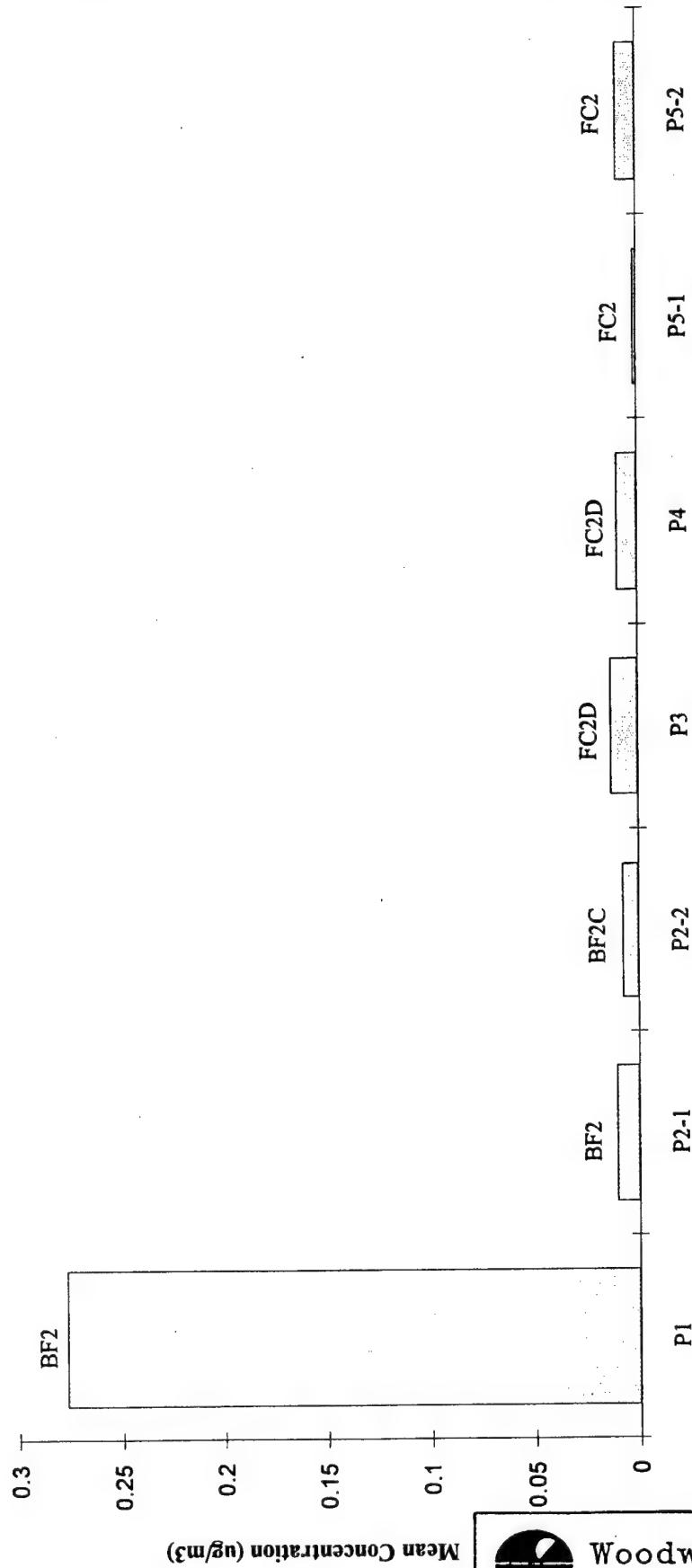
CHKD BY :

DATE :

22787E

4.7-5

Dieldrin By Phase



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

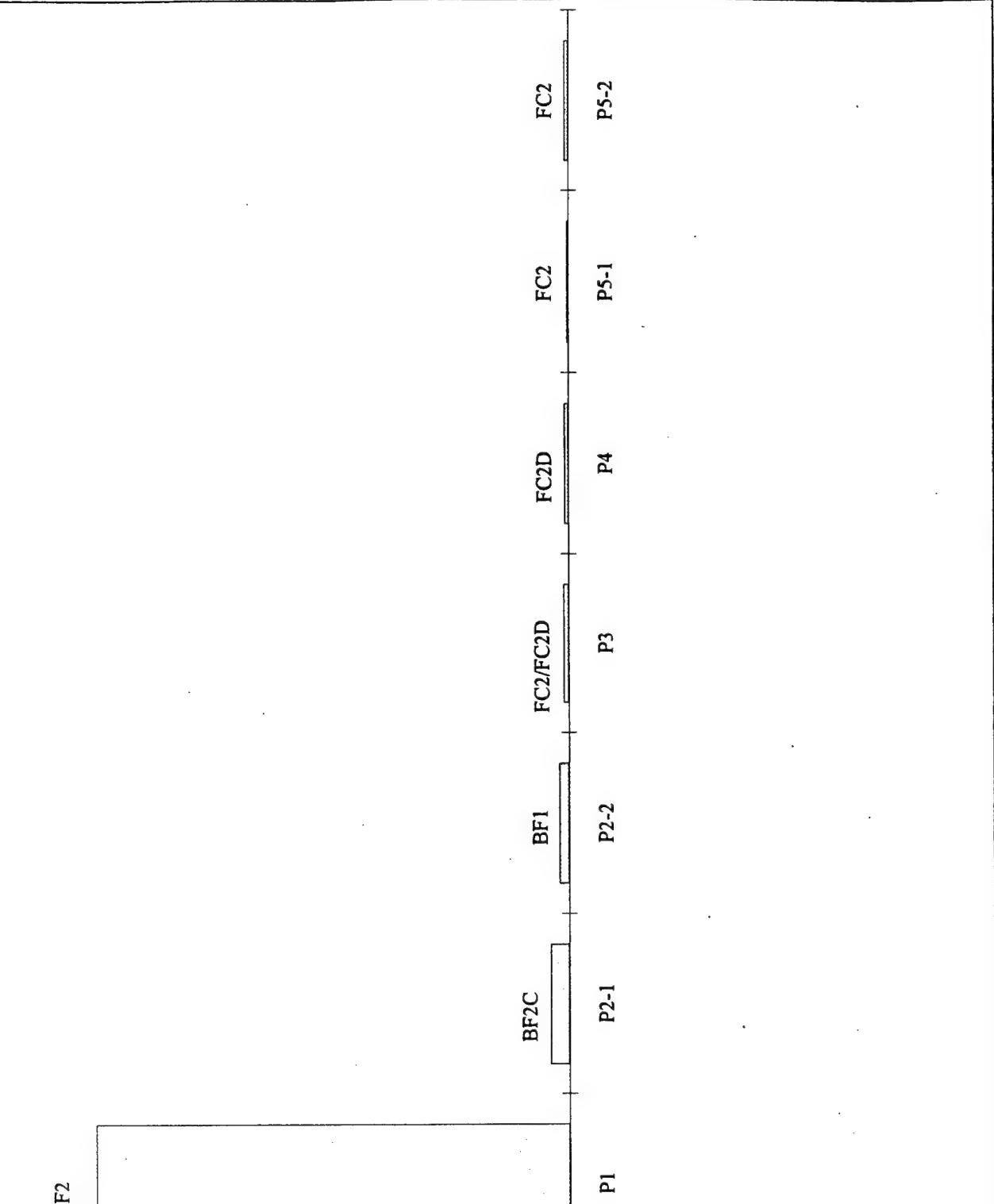
DIELDRIN BY PHASE

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	DATE :	PROJECT NO:	FIG. NO :
CHKD BY :	DATE :	22787E	4.7-6

Endrin By Phase



Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

ENDRIN BY PHASE

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :

DATE :

PROJECT NO:

FIG. NO :

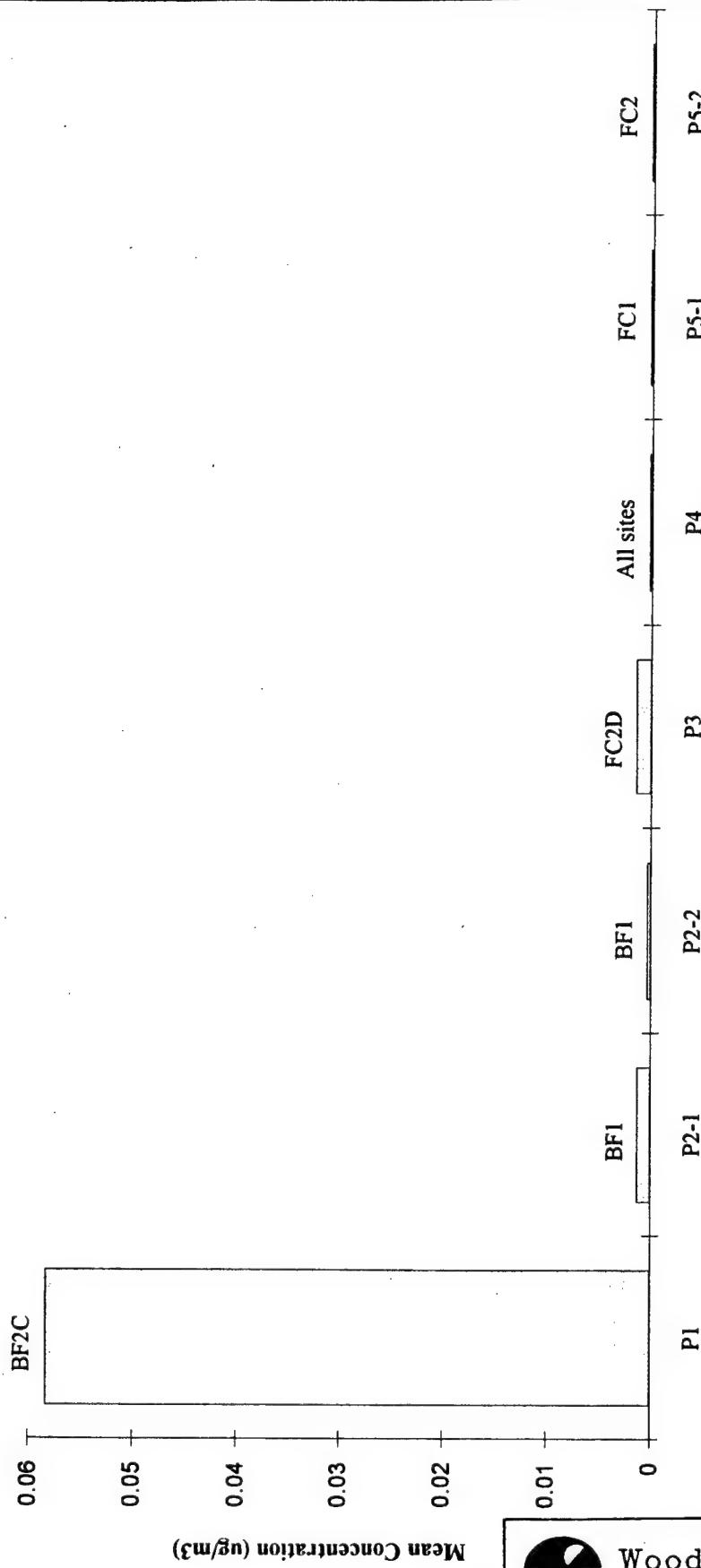
CHKD BY :

DATE :

22787E

4.7-7

Isodrin By Phase



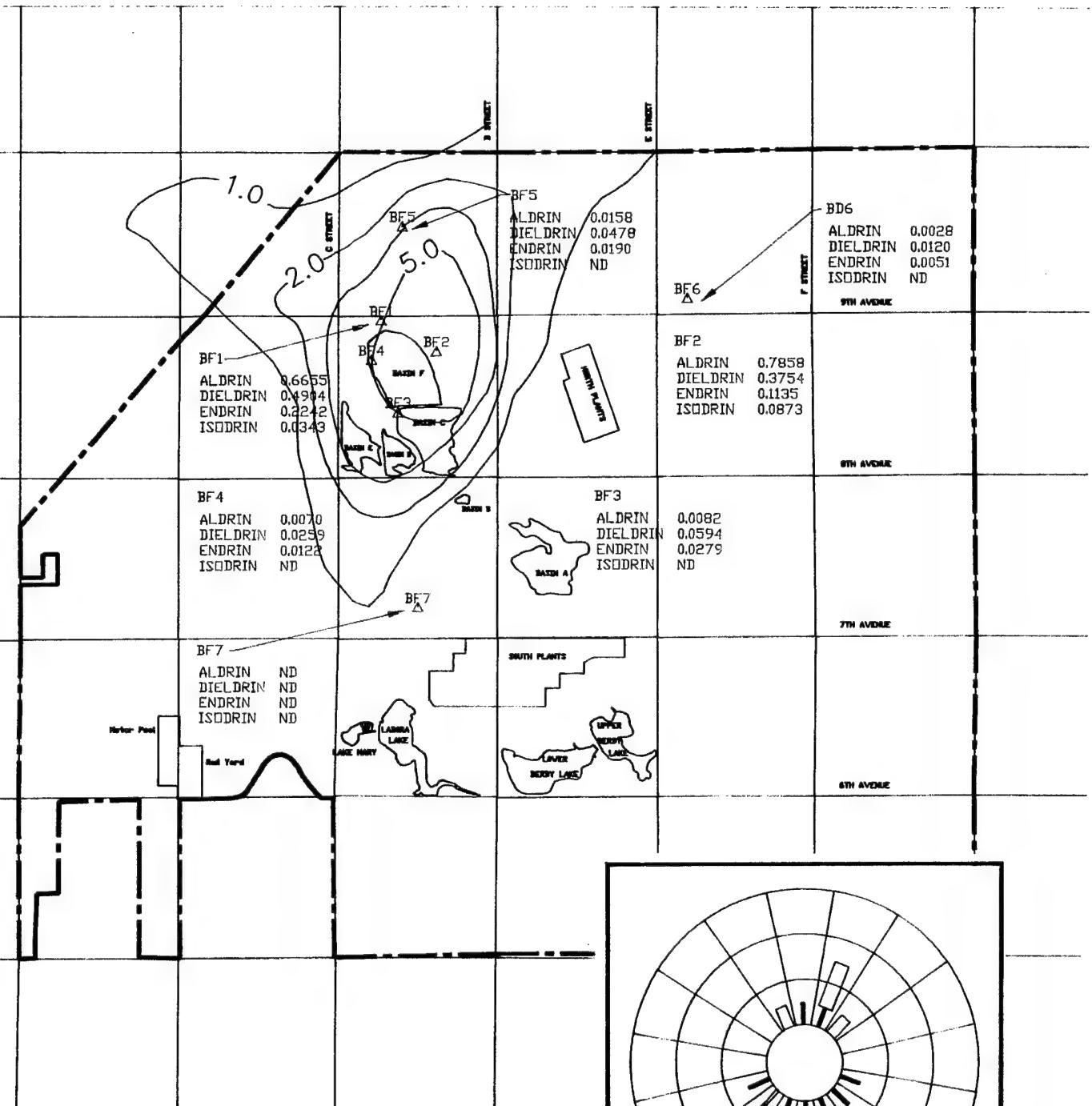
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

ISODRIN BY PHASE

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	DATE :	PROJECT NO.:	FIG. NO.:
CHKD BY :	DATE :	22787E	4.7-8



LEGEND

BF1 Monitoring Location
 ND = Non-Detectable
 24 Hour Maximum ($\mu\text{g}/\text{m}^3$)

5000 0 5000 10000
SCALE Feet



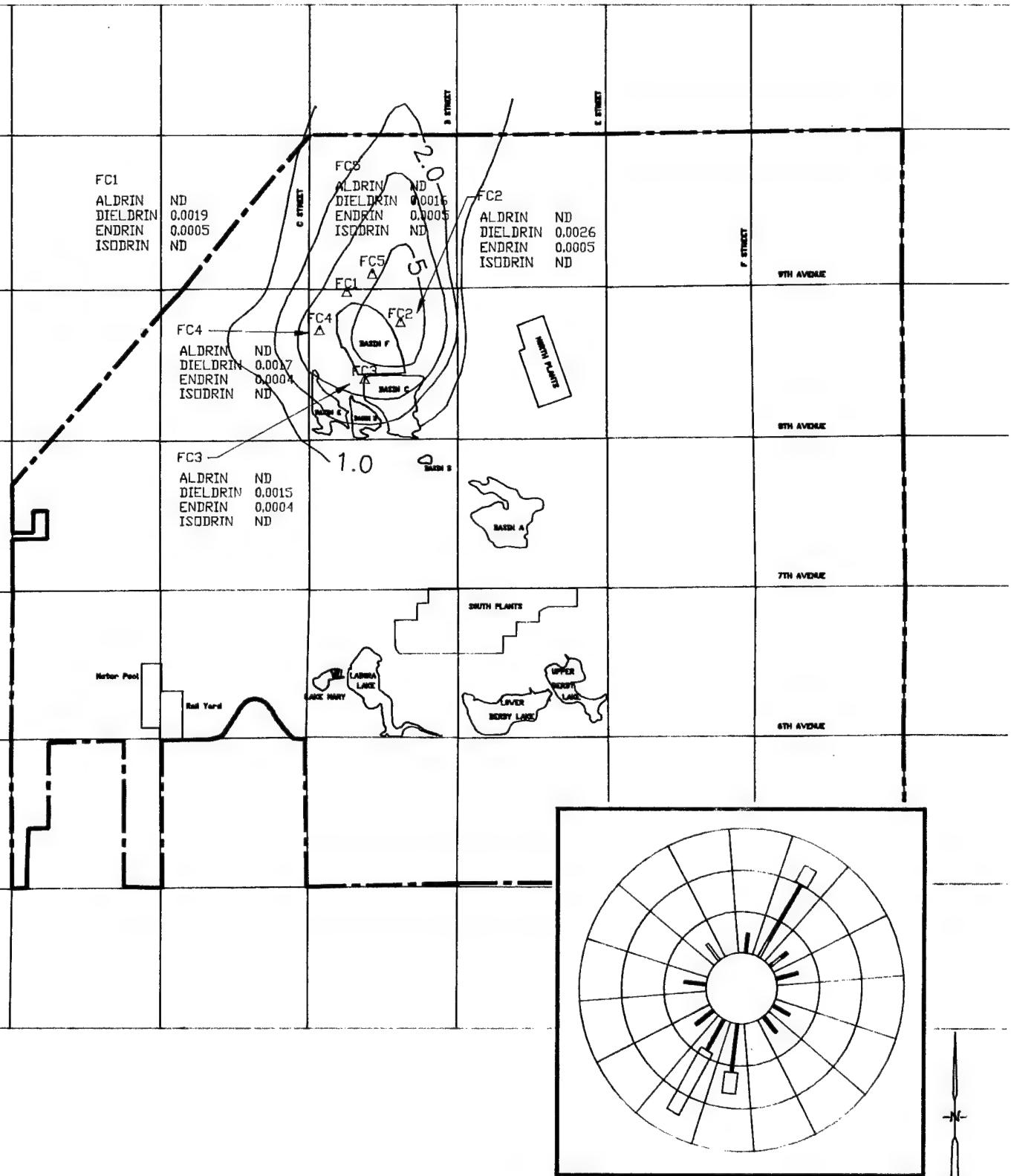
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

x/Q Dispersion and Basin F Pesticides For 8/23/88
Basin F Air Quality Data
Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	dwb	DATE :	5/5/92	PROJECT NO:	FIG. NO :
CHKD BY :	.	DATE :	.	22787E	4.7-9



LEGEND

FC1-F Monitoring Location
 ND = Non-Detectable
 24 Hour Maximum ($\mu\text{g}/\text{m}^3$)



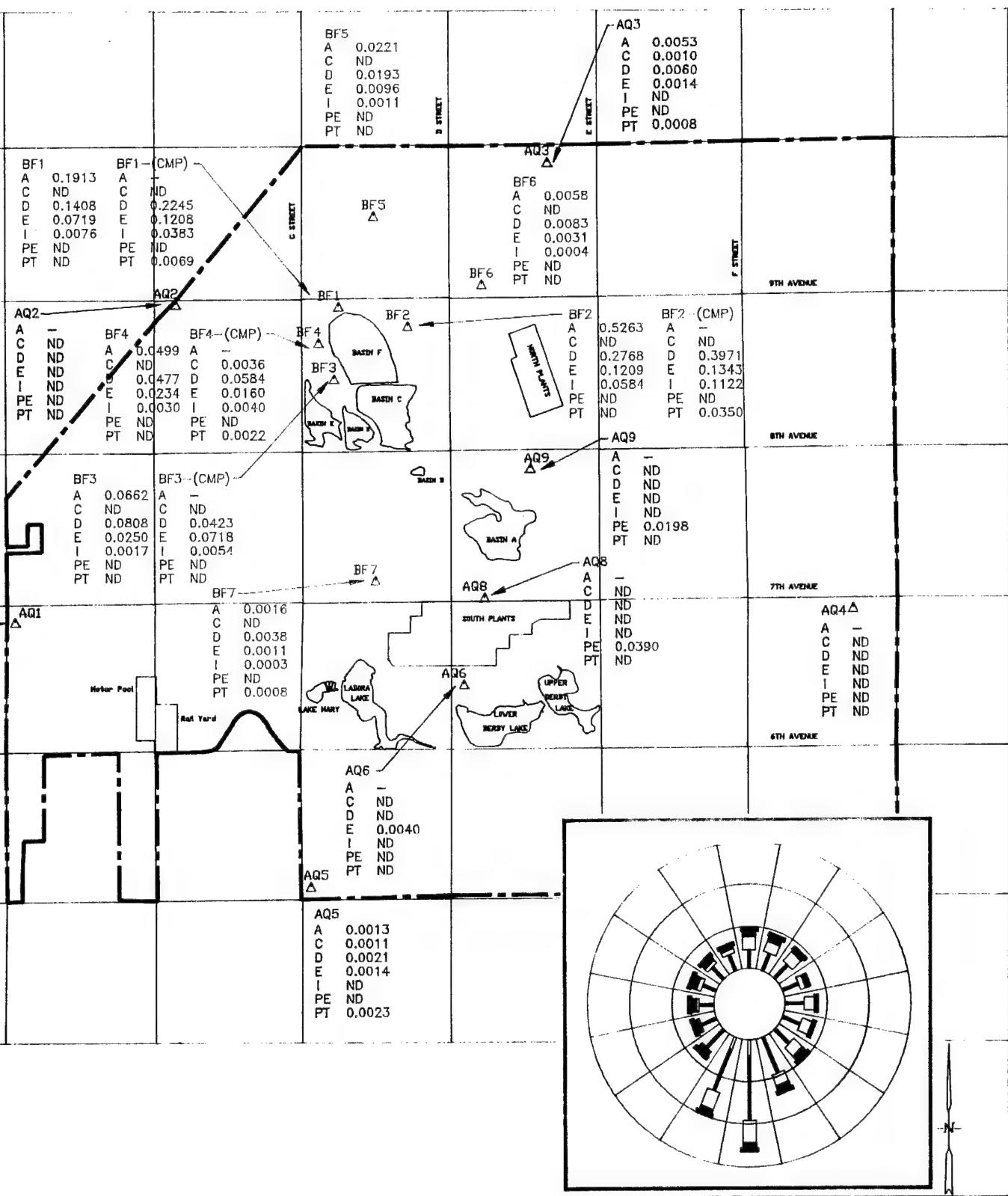
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

x/Q Dispersion and IRA-F Pesticides For 9/8/90
IRA-F Air Quality Data
Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	dwb	DATE :	5/5/92	PROJECT NO:	FIG. NO :
CHKD BY :	.	DATE :	.	22787E	4.7-10



LEGEND

- BF1** Δ CMP FC Sites (Formerly IRA-F)
- AQ5** Δ Comprehensive Monitoring Location
- A = Aldrin
C = Chlordane
D = Dieldrin
E = Endrin
I = Isodrin
PE = PDDDE
PT = PPDDT

Annual Average ($\mu\text{g}/\text{m}^3$)



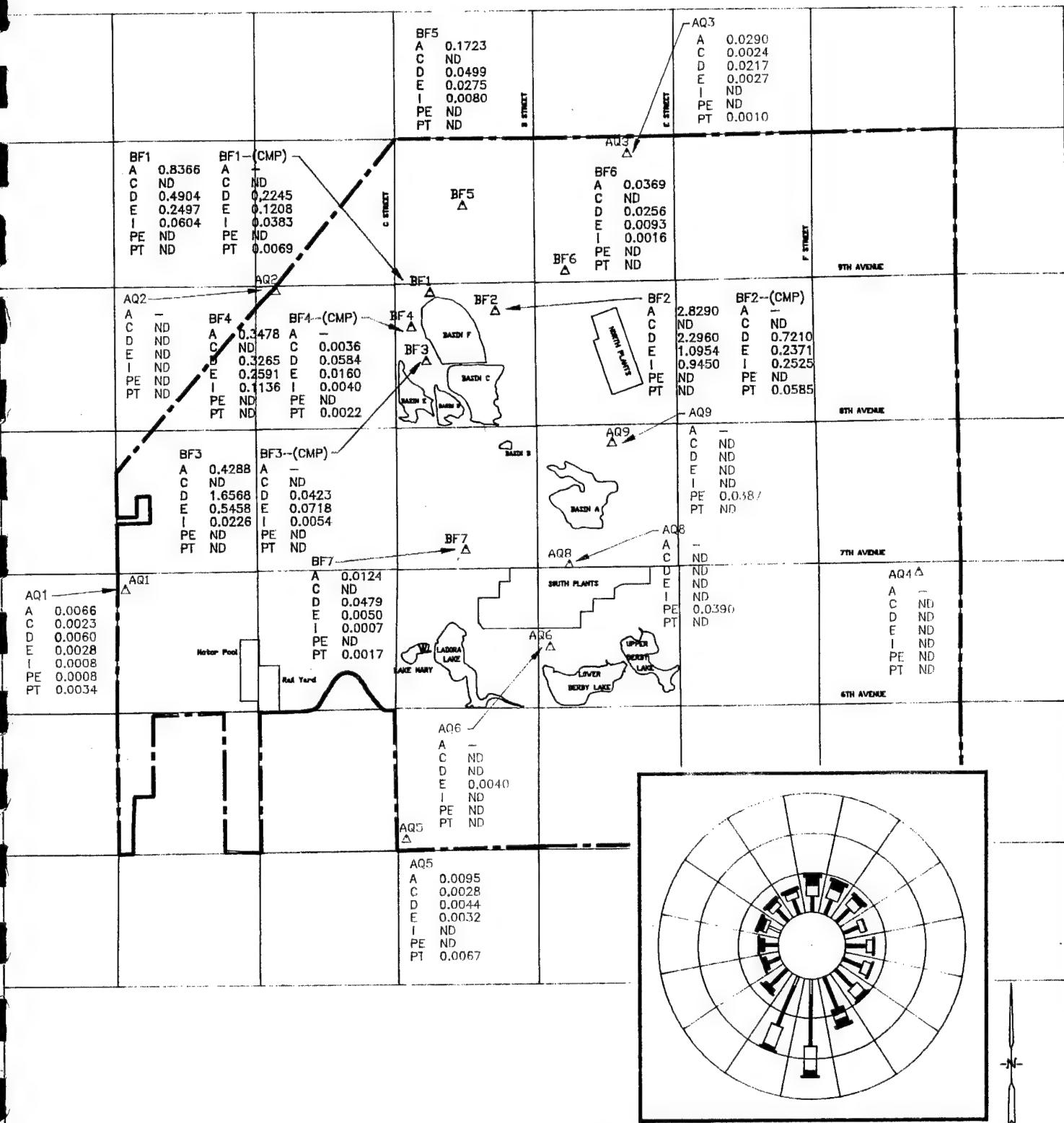
Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

Composite OCP Analysis for Phase 1
CMP Air Quality Data
Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY :	dwb	DATE :	5/5/92	PROJECT NO:		FIG. NO :
CHKD BY :	.	DATE :	.	22787E		4.7-11



L E G E N D

BF1 CMP FC Sites (Formerly IRA-F)

AQ5 Comprehensive Monitoring Location

A	=	Aldrin
C	=	Chlordane
D	=	Diedrin
E	=	Endrin
I	=	Isodrin
PE	=	PPDDE
PT	=	PPDDT

24 Hour Maximum (ug/m³)



Woodward-Clyde Consultants

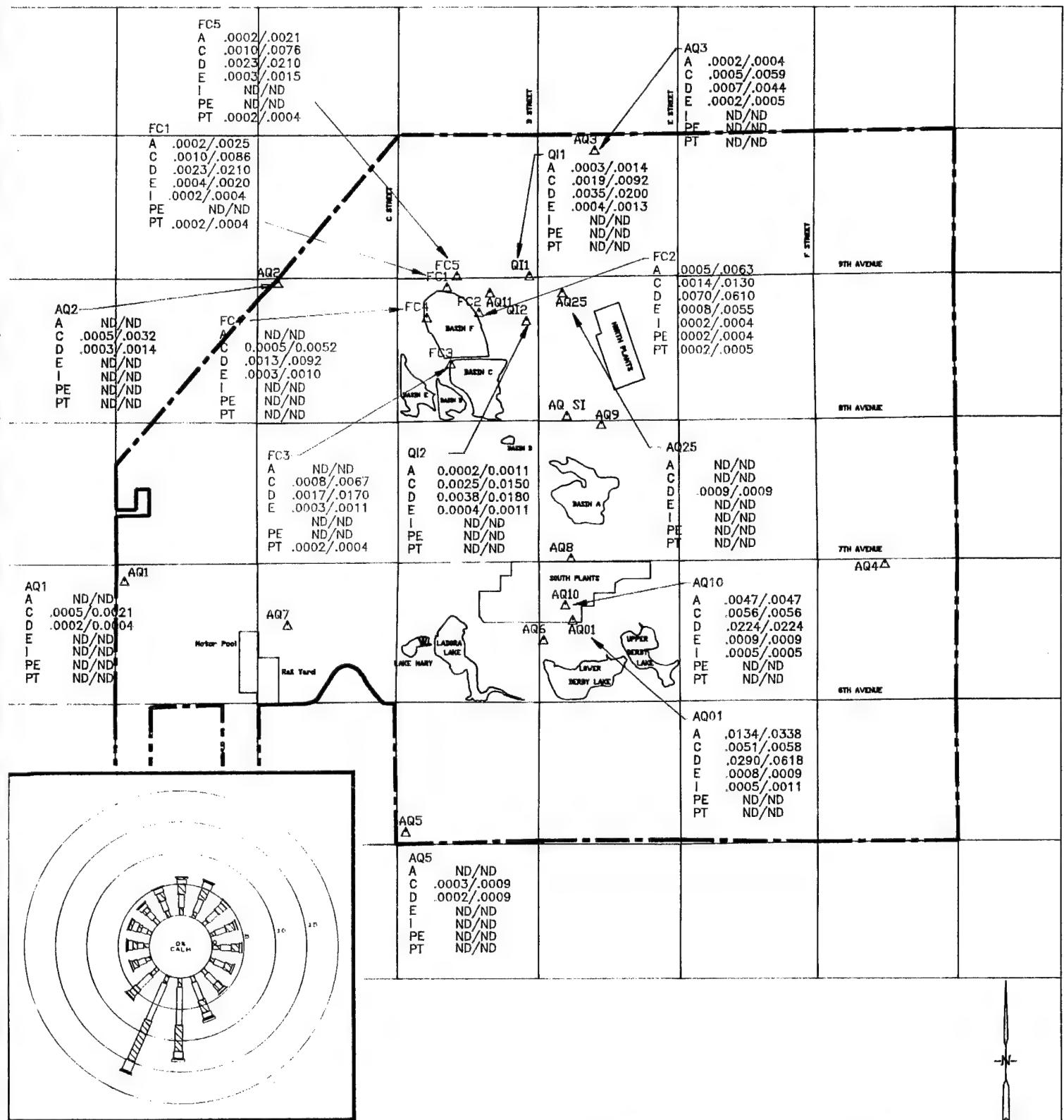
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

**Composite OCP Analysis for Phase 1
CMP Air Quality Data
Rocky Mountain Arsenal**

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb	DATE : 5/5/92	PROJECT NO:	FIG. NO :
CHKD BY : .	DATE : .	22787E	4.7-11A



LEGEND

FC3 **CMP FC Sites (Formerly IRA-F)**

AQ5 Comprehensive Monitoring Location

A	=	Aldrin
C	=	Chlordane
D	=	Diedrin
E	=	Endrin
I	=	Isodrin
PE	=	PPDDE
PT	=	PPDDT

Annual Average / 24 Hour Maximum (ug/m³)

ND - Non-Detectable



Woodward-Clyde Consultants

ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

Composite OCP Analysis for Phase 5 CMP Air Quality Data Rocky Mountain Arsenal

U.S. Program Manager

Rocky Mountain Arsenal

DRWN BY : dwb DATE : 5/5/92

PROJECT NO: FIG. NO :

CHKD BY : DATE :

22787E | 4.7-12

4.8 AIR STRIPPER OFF-GAS TESTING

This section provides results of air stripper off-gas testing at the A-Neck groundwater treatment facility. The primary purpose of the A-Neck facility is to treat the ground water moving northwest from Basin A. This facility contains an adjacent room in which an air stripper is operated mainly for treatment of ground water from a well near Basin F. Off-gas sampling was conducted during the period from February 17, 1991, to April 11, 1991. The sampling was conducted as part of the CMP Air Quality Program 6-month extension. Air stripper sampling was initially conducted as part of the IRA-F Special Studies Task from October 1990 until January 1991. Results from those events were previously reported to PMRMA.

The air stripper system is located in the south room of the A-Neck groundwater treatment building. Water supplied to the air stripper for treatment is obtained from a ground-water extraction well located near the Basin F area. Diagrams of the air stripper off-gas flow and sampling port configurations are presented in Figures 4.8-1 and 4.8-2. Off-gas samples were obtained at three locations: upstream, prior to carbon adsorption; midstream, after treatment in the first carbon unit; and downstream, following the second carbon unit and exhaust blower. The carbon adsorption units are filled with granular activated carbon and are designed for vapor phase contaminant reduction in air flow streams. Sorbent tubes and Tedlar bags were used for sample collection at the three off-gas sample ports. Background concentrations were determined by collection of ambient air in Tedlar bags at a position outside the building. All samples collected in Tedlar bags were immediately analyzed on-site using OVA and HNu direct-reading instruments. Sorbent tube samples were shipped to the laboratory, Analytical Technologies, Inc., (ATI) Pensacola, for analysis. In communications with PMRMA, permission was received to utilize ATI's methods for off-gas sample analysis.

In each sampling event, sorbent tube samples were aerated with off-gas for approximately 80 minutes. A volume of 10 liters of off-gas was typically sampled using the tube sets. The samples obtained in Tedlar bags were collected in a period of approximately 3 minutes. A series of three bag samples were collected during the tube aeration periods. During weekly events, the normal testing routine entailed the collection of sorbent tube samples at the midstream port using a front and back Tenax

tube set in series. During monthly events, the normal testing routine entailed collection of sorbent tube samples at the midstream and downstream ports using Tenax, Tenax back-up, and XAD tubes in series. Monthly events also included a collocated tube sample set at the midstream port and a set of Tenax and XAD field blanks.

A synopsis of sampling efforts is shown in Table 4.8- 1, including the calendar week, test date, and type of test performed. In the period after April 11, 1991, operation of the air stripper was interrupted. Low water levels in the Basin F ground-water extraction well were cited by the plant operator as the primary cause for operation interruptions. A summary of the real-time OVA and HNu readings for each event is shown in Table 4.8-2. For each data point, a set of three consecutive samples were collected using the Tedlar bags to obtain the background compensated average.

The overall direct reading instrument averages indicate that concentrations measured at the midstream and downstream ports are typically lower than those measured at the upstream port. Certain minor exceptions to this can be seen in Table 4.8-2. Any direct cause for these observations is not apparent. One possible reason is loss of sorptive capacity in the second stage carbon unit which had been in operation until after those tests were performed. The second stage carbon adsorption was switched from the middle position unit to the northern unit prior to the March 21, 1991, testing event. This change in flow configuration is depicted in Figures 4.8-1 and 4.8-2.

The analyte list for weekly testing events included bicycloheptadiene, chloroform, dicyclopentadiene, and methylene chloride. The analyte list for monthly testing events included: benzene, 1, 1-dichloroethylene, total 1,2-dichloroethylene, tetrachloroethylene, trichloroethylene, diisopropylmethyl phosphonate, dimethylmethyl phosphate, Method 8270 acid and base neutral extractables, and tentatively identified compounds. Results from analysis of sorbent sample tubes, are given in Table 4.8-3 through 4.8-8. Overall, results of analyses of Tenax samples indicate that chloroform was the target compound measuring the highest concentration most frequently. Similar results were observed in previous air stripper testing reports. Methylene chloride was the second most prevalent target compound detected in the testing events performed during this report period. Field blank levels for chloroform and methylene chloride indicate that media background levels of these compounds were not of significant levels. The downstream

Tenax sample reporting the highest concentration was chloroform, at 2.779 mg/m³ (2/28/91). The tentatively identified compound of highest concentration found among TIC's in Tenax samples was 1,2-dichloroethane, at 0.047 mg/m³ (2/28/91).

Analyses of XAD samples indicate that diisopropylmethyl phosphonate (DIMP) and dimethylmethyl phosphate (DMMP) were below detection levels in all cases in which XAD was utilized. No tentatively identified compounds were observed in the XAD tube samples. The Method 8270 acid and base neutral extractables target compounds were below detectable limits in all reported cases, except during the March 27, 1991, testing event. In those XAD tubes, Bis (2-ethylhexyl) phthalate was found in the midstream collocated, downstream, and field blank samples. The presence of Bis (2-ethylhexyl) phthalate in the March 27, 1991, XAD field blank indicates that the other reported values for that compound in the associated samples may be due to field or analytical contamination or artifacts.

The predominance of non-detects in the March 27, 1991, analytical report is unusual. One possible cause may be that the air stripper feed water was being recirculated through the stripper tower during that testing event. PMRMA personnel decided not to have off-gas testing performed again during periods in which water recirculation was occurring.

TABLE 4.8-1
SYNOPSIS OF AIR STRIPPER OFF-GAS TESTING EFFORTS

Week of	Test Date	Testing Performed
2/17/91	2/21/91	HNu and OVA Test
2/24/91	2/28/91	Monthly Test
3/3/91	3/5/91	Weekly Test
3/10/91	3/11/91	Weekly Test
3/17/91	3/21/91	Weekly Test
3/24/91	3/27/91	Monthly Test
3/31/91	4/4/91	Weekly Test
4/7/91	4/11/91	Weekly Test

TABLE 4.8-2
SUMMARY OF AVERAGE HNu AND OVA RESULTS (ppm)
FOR AIR STRIPPER OFF-GAS TESTING

Event	Upstream ¹	Midstream ¹	Downstream ¹	Zero Air	Ambient Air
OVA					
2/21/91	1.1	NT	0.8	0.0	1.0
2/28/91	1.2	0.8	0.6	0.0	1.2
3/5/91	1.1	1.1	1.1	0.0	1.0
3/11/91	1.1	1.4	1.3	0.0	0.9
3/21/91	0.4	0.0	0.1	0.0	0.9
3/27/91	0.4	0.0	0.1	0.0	0.8
4/4/91	0.4	0.0	0.0	0.0	0.9
4/11/91	0.0	0.0	0.0	0.0	0.8
Average	0.7	0.5	0.5	0.0	0.9
HNu					
2/21/91	0.4	NT	0.1	0.0	0.0
2/28/91	0.3	0.1	0.1	0.0	0.0
3/5/91	0.2	0.1	0.0	0.0	0.0
3/11/91	0.5	0.2	0.1	0.0	0.1
3/21/91	0.3	0.2	0.1	0.0	0.0
3/27/91	0.5	0.2	0.2	0.0	0.0
4/4/91	0.4	0.1	0.1	0.0	0.0
4/11/91	3.5	0.7	0.9	0.0	0.0
Average	0.8	0.3	0.2	0.0	0.0

¹ Background Compensated

NT - Not taken

TABLE 4.8-3
AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION
FOR SAMPLE DATE 02/28/91

	Sample Location: Sample Type:	Midstream Tenax	Midstream Tenax (collocated)	Downstream Tenax	Field Blank Tenax	Midstream XAD (collocated)	Midstream XAD	Downstream XAD	Field Blank XAD
	Sample Number: Units:	0288MT1,2 mg/m ³	0288MCTR1,2 mg/m ³	0228DT1,2 mg/m ³	0228FBT ug	0228MX mg/m ³	0228MCX mg/m ³	0228DX mg/m ³	0228FBX ug
Analyte - Tenax									
Benzene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Bicycloheptadiene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroform	3.035	3.076	2.779						
1,1-Dichloroethylene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total 1,2-Dichloroethylene	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Dicyclopentadiene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Methylene chloride	0.025	0.025	0.025	0.025	0.025	0.018	0.018	0.018	0.018
Tetrachloroethylene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethylene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
(Greatest tentatively identified compound)	0.047 (1,2-Dichloro-ethane)	0.004 (Trichloro-fluoromethane)	0.013 (Trichloro-fluoromethane)	0.001 (Trichloro-fluoromethane)					
Analyte - XAD									
Diisopropylmethyl phosphonate				BDL	BDL	BDL	BDL	BDL	BDL
Dimethylmethyl phosphate				BDL	BDL	BDL	BDL	BDL	BDL
Method 8270 Acid and BN Extractables, Total List				ALL BDL	ALL BDL	ALL BDL	ALL BDL	ALL BDL	ALL BDL
(Greatest tentatively identified compound)				NO TICs	NO TICs	NO TICs	NO TICs	NO TICs	NO TICs
BDL - Below Detection Limits									

TABLE 4.8-4
AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION
FOR SAMPLE DATE 03/05/91

Sample Location:	Midstream	Field Blank
Sample Type:	Tenax	Tenax
Sample Number:	0305MT1,2	0305FBT
Units:	mg/m ³	ng
Analyte - Tenax		
Bicycloheptadiene	BDL	
Chloroform	2.702	
Dicyclopentadiene	BDL	
Methylene chloride	0.012	35

BDL - Below Detection Limits

TABLE 4.8-5
AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION
FOR SAMPLE DATE 03/11/91

Sample Location:	Midstream	Midstream
Sample Type:	Tenax	XAD
Sample Number:	031191MT1,2	031191MX
Units:	mg/m ³	mg/m ³
Analyte - Tenax		
Bicycloheptadiene	BDL	
Chloroform	2.567	
Dicyclopentadiene	BDL	
Methylene chloride	0.223	
Analyte - XAD		
Diisopropylmethyl phosphonate		BDL
Dimethylmethyl phosphate		BDL

BDL - Below Detection Limits

TABLE 4.8-6

**AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION
FOR SAMPLE DATE 03/21/91**

Sample Location:	Midstream
Sample Type:	Tenax
Sample Number:	032191MT1,2
Units:	mg/m ³
Analyte - Tenax	
Bicycloheptadiene	BDL
Chloroform	0.323
Dicyclopentadiene	BDL
Methylene chloride	0.930

BDL - Below Detection Limits

TABLE 4.8-7
AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION
FOR SAMPLE DATE 03/27/91

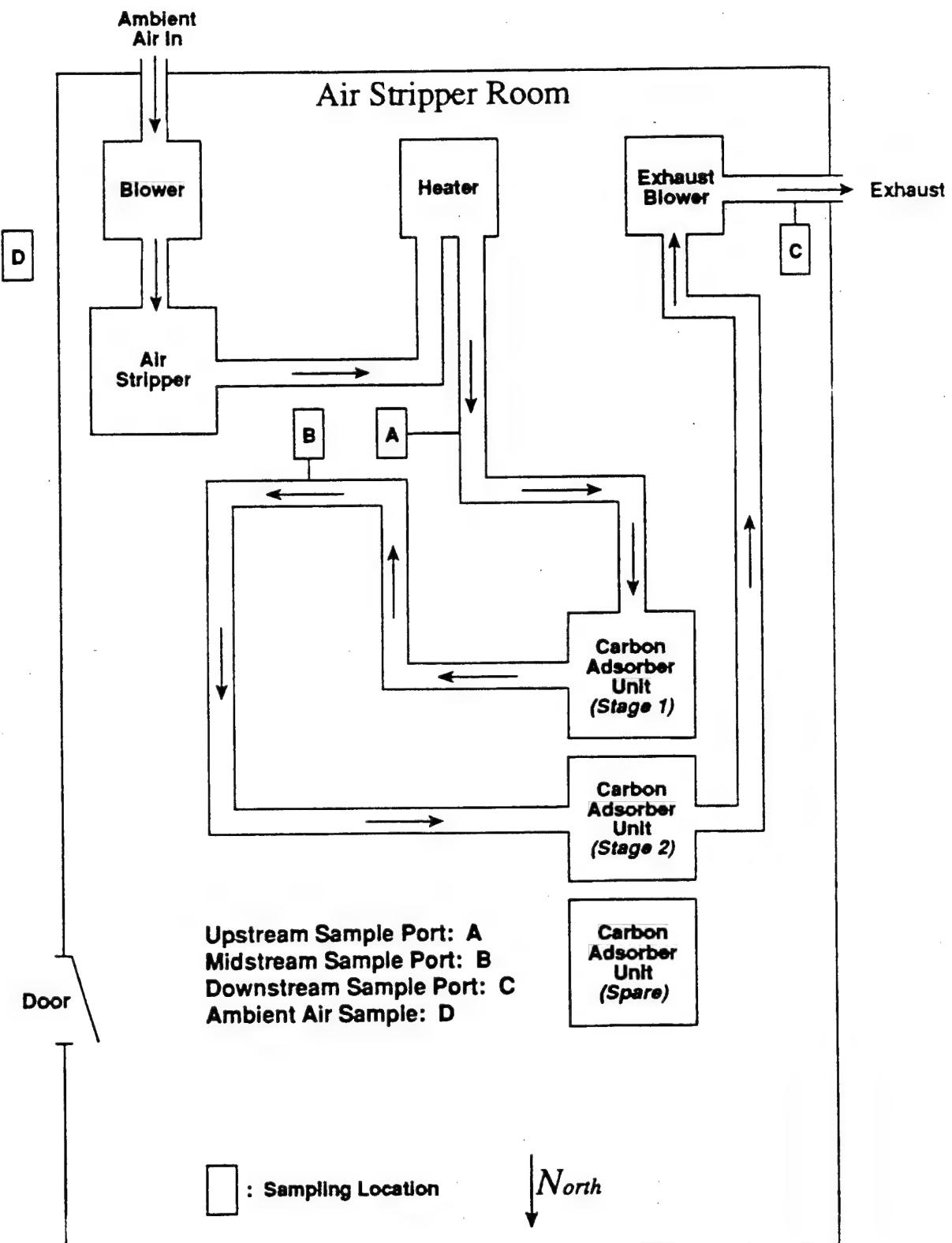
	Sample Location: Sample Type:	Midstream Tenax	Midstream Tenax (collocated)	Downstream Tenax	Field Blank Tenax	Midstream XAD	Midstream XAD (collocated)	Downstream XAD	Field Blank XAD
	Sample Number: Units:	032791MT _{1,2} mg/m ³	032791MT _{1,2} mg/m ³	032791DT _{1,2} mg/m ³	032791FBT ng	032791MX mg/m ³	032791CX mg/m ³	032791DX mg/m ³	032791FBX μg
Analyte - Tenax									
Benzene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Bicycloheptadiene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroform	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethylene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total 1,2-Dichloroethylene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Diethylpentadiene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Methylene chloride	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Tetrachloroethylene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethylene	BDL	BDL	BDL	BDL	NO TICs				
(Greatest tentatively identified compound)									
Analyte - XAD									
Düisopropylmethyl phosphonate					BDL	BDL	BDL	BDL	BDL
Dimethylmethyl phosphate					BDL	BDL	BDL	BDL	BDL
Method 8270 Acid and BN Extractables, Total List					ALL BDL except* * 2,2	ALL BDL except* * 1,1	ALL BDL except* * 1,1	ALL BDL except* * 2,1	ALL BDL except* * 2,1
(Greatest tentatively identified compound)					(Bis(2-Ethyl hexyl) Phthalate)	(Bis(2-Ethyl hexyl) Phthalate)	(Bis(2-Ethyl hexyl) Phthalate)	(Bis(2-Ethyl hexyl) Phthalate)	(Bis(2-Ethyl hexyl) Phthalate)
BDL - Below Detection Limits					NO TICs				

TABLE 4.8-8

**AIR STRIPPER OFF-GAS SAMPLING ANALYTE CONCENTRATION
FOR SAMPLE DATE 04/11/91**

Sample Location:	Midstream
Sample Type:	Tenax
Sample Number:	041191MT1,2
Units:	mg/m ³
Analyte - Tenax	
Bicycloheptadiene	BDL
Chloroform	BDL
Dicyclopentadiene	BDL
Methylene chloride	0.017

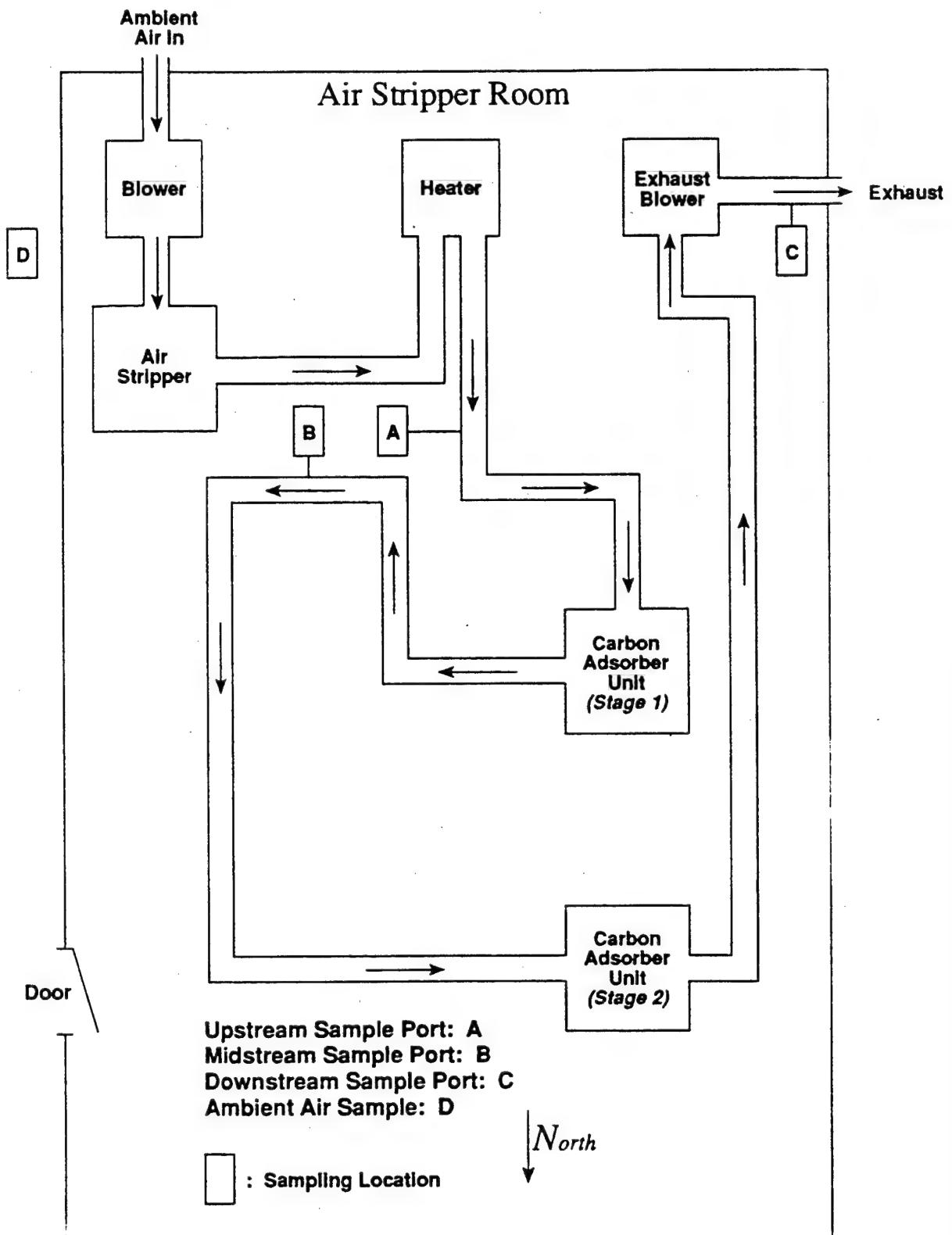
BDL - Below Detection Limits



Job No. :	22787E
Prepared by :	T.R.H.
Date :	9/4/92

**AIR STRIPPER OFF-GAS FLOW DIAGRAM
AND SAMPLING LOCATIONS**
2/21/91, 2/28/91, 3/5/91, 3/11/91





Job No. :	22787E
Prepared by :	T.R.H.
Date :	9/4/92

**AIR STRIPPER OFF-GAS FLOW DIAGRAM
AND SAMPLING LOCATIONS**
3/21/91, 3/27/91, 4/4/91, 4/11/91



4.9 REAL-TIME CAP AND VENT MONITORING

4.9.1 Program Description

Real-time monitoring of the Basin F waste pile cap, the restored Basin F floor, and the vents on the waste pile, around Pond A, and on the three storage tanks for the Basin F liquid was conducted to characterize emissions of the sources to aid in assessing their possible impact on ambient air quality. This involved taking real-time readings of total organics using both an OVA and an HNu.

During construction of the Basin F waste pile, a total of 25 passive off-gas release vents were installed through the liner to relieve potential air pressure gradients from recurring atmospheric pressure changes and from internal vaporization of contaminants. The vents are spaced in an irregular grid across the waste pile, as indicated in Figure 4.9-1, and the vents are numbered in a random numbering scheme. The height of each vent varies with the depth of the waste pile cap and ranges from 1- to 3-ft above ground. Vent pipes are 6 inches in diameter and terminate in a down-curved opening.

Real-time monitoring of the waste pile vents took place on April 22 and July 7, 1991. It consisted of readings taken at about 1 in. below the vent opening on the downwind side, during periods when winds were light (less than 10 mph) and atmospheric pressure was dropping. Readings were taken with an OVA and HNu to sense total organics. A hand pump was used to collect indicator tube readings for ammonia. Each sample reading was taken over an approximate 30-second interval.

Real-time readings of the waste pile cap surface were also taken. The OVA and HNu were each fitted with an extension tube ending in a small funnel. The technician traversed the waste pile cap in a predetermined pattern and collected representative readings at a total of 126 marked locations regularly spaced across the waste pile. These locations are also shown in Figure 4.9- 1. The sample was drawn from approximately 1 in. above ground at each location, and real-time readings were recorded on field data sheets.

Similar readings were taken from the restored Basin F floor, which had been covered with a clay and topsoil cap. The Basin F floor readings were taken at 115 regularly spaced locations marked by sandbags, as depicted in Figure 4.9-2. Weather conditions and the physical appearance of the floor during each sampling episode were recorded prior to commencement of sampling.

Pond A is a double-lined liquid storage pond located just north of Basin F. The pond is covered with a high density polyethylene cover and has four special vents, one in the middle of each side of the pond. The vents are equipped with trip valves that open to allow emission of gases and close to prevent entrainment of air beneath the pond cover. As a result, the pond gases are emitted in short pulses. Sampling the pond vents required a sample duration that spanned several pulses of the trip valve. Pond A vents were sampled with the real-time monitors once during the CMP FY91E period; vent locations are illustrated on Figure 4.9-2.

The three storage tanks for the Basin F liquid are covered by metal roofs with passive vents atop each tank. The sampling crew did not have access to the roof, but was able to perform real-time sampling of the vapors through a Tygon tubing extension for the analyzer probes. Real time tank vapor readings were taken with the OVA and HNu once during the extension. The three storage tanks are shown in Figure 4.9-2.

4.9.2 Real-Time Monitoring Results

The results of the real-time monitoring conducted at Basin F are summarized in Table 4.9-1. Data sheets for all monitoring events are presented in Appendix E. Overall, the data show that the OVA and HNu readings were quite low. HNu levels for all of the locations were lower than, but generally followed the same pattern as the OVA levels. Furthermore, at all monitoring locations the levels dropped to background levels within a few inches of the vent opening.

The vents on the waste pile with the highest readings were dispersed over the entire area, indicating that there was no main portion of the pile that would be considered an identifiable source of elevated emissions.

The pond vent readings show that the highest level occurred on the upwind (west) side of the pond, but all levels were too low to be able to draw conclusions about the nature of the pond as an emissions source.

The storage tank results indicate the potential for a very small source of emissions.

The ambient monitoring of the waste pile cap and restored basin floor yielded no detections on the OVA or HNu.

The results of the real-time monitoring efforts indicate that very little contamination was emitted by these facilities.

TABLE 4.9-1

RESULTS OF REAL-TIME BASIN F VENT AND CAP MONITORING*

Summary of Real-time Waste Pile Vent OVA Results, in ppm

Date	Average	Maximum	Vent Number
4/22/91	1.1	3.4	22
7/07/91	1.1	4.4	9

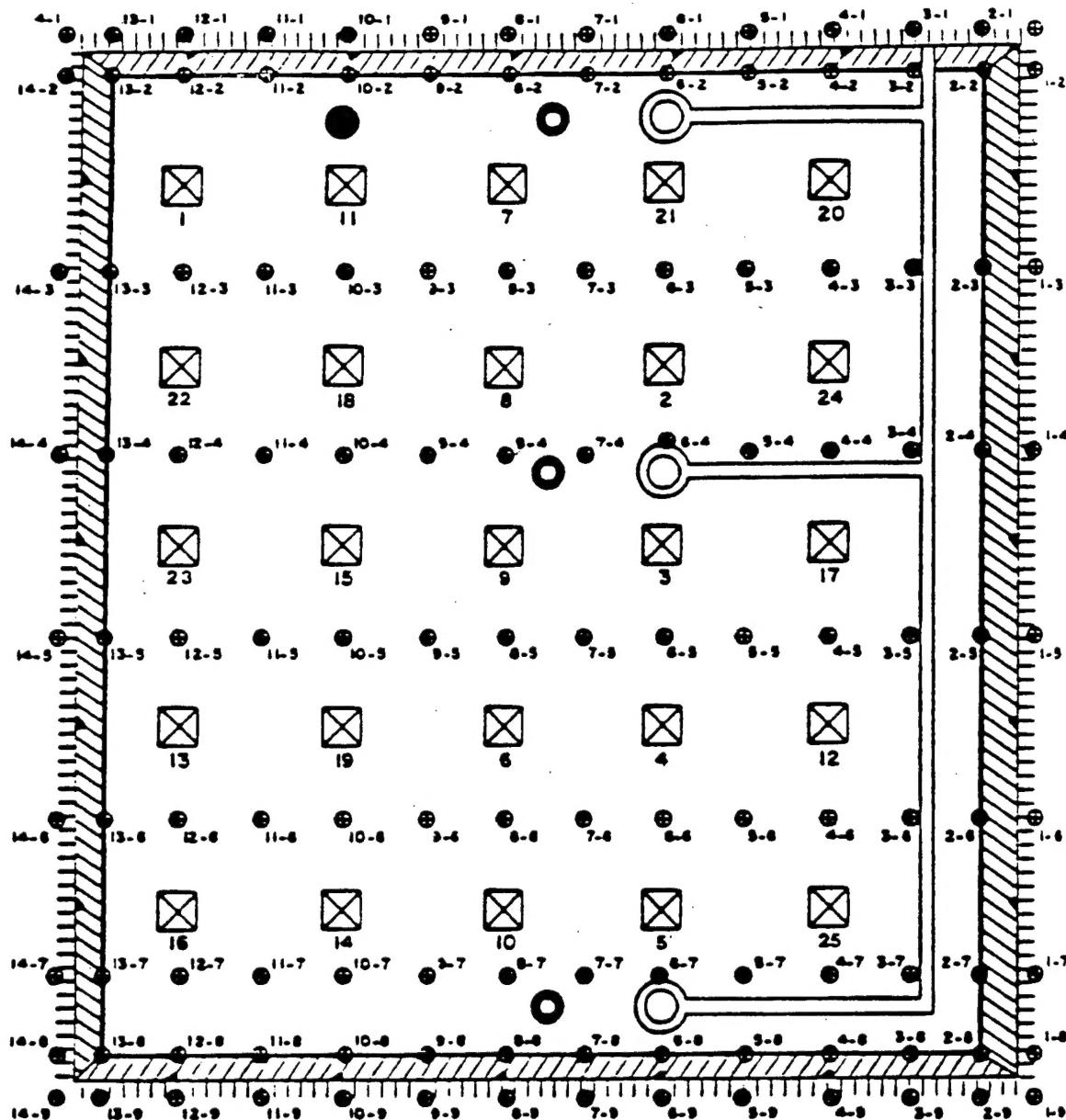
Summary of Real-time Pond A Vent OVA Results in ppm

Date	North	East	South	West	Average	Maximum	Wind Direction
7/19/91	0.0	0.0	0.2	1.4	0.4	1.4	NW

Summary of Real-time Storage Tank Vent Results, in ppm

Date	West	East	South	Average	Maximum
7/19/91	8.0	6.2	12.2	8.8	12.2

* = There were no detections on the OVA or HNu for the waste pile cap and the restored Basin F floor cap.

Legend

- Vent with Existing Vent Number
- Sand Bags
- Baseplate Standpipe
- Detection Sump and Baseplate Standpipe
- Leachate Collection Sump and Baseplate Standpipe

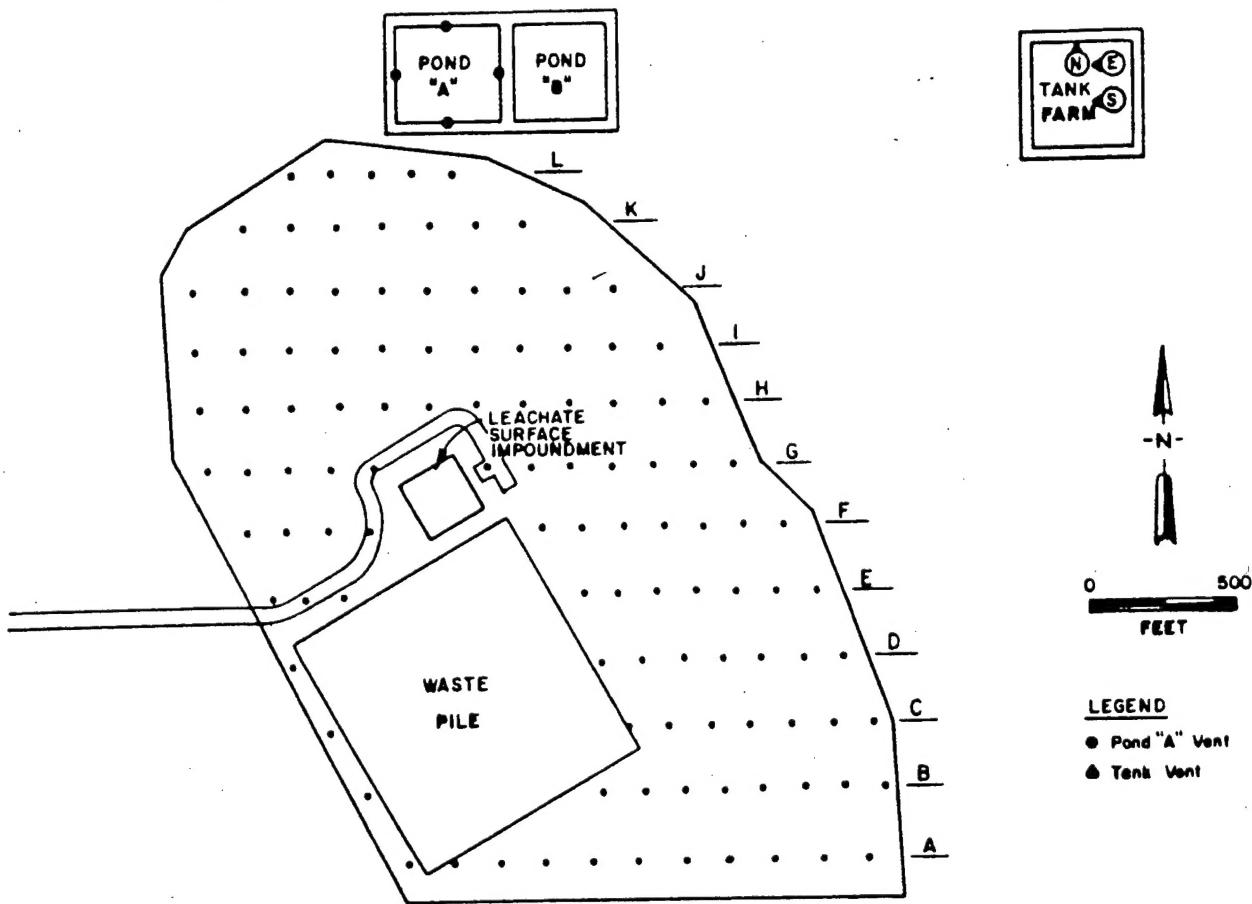


Not to Scale

Job No. :	22787E
Prepared by :	T.R.H.
Date :	9/4/92

LOCATIONS OF WASTE PILE VENTS AND
SANDBAGS FOR REAL-TIME MONITORING

FIG. 4.9-1

LEGEND

- Pond "A" Vent
- ▲ Tank Vent

Job No. :	22787E
Prepared by :	T.R.H.
Date :	9/4/92

LOCATION OF TANK FARM, PONDS A & B,
WASTE PILE AND RESTORED BASIN F



FIG. 4.9-2